ORIGINS

• Journal of the Biblical Creation Society •

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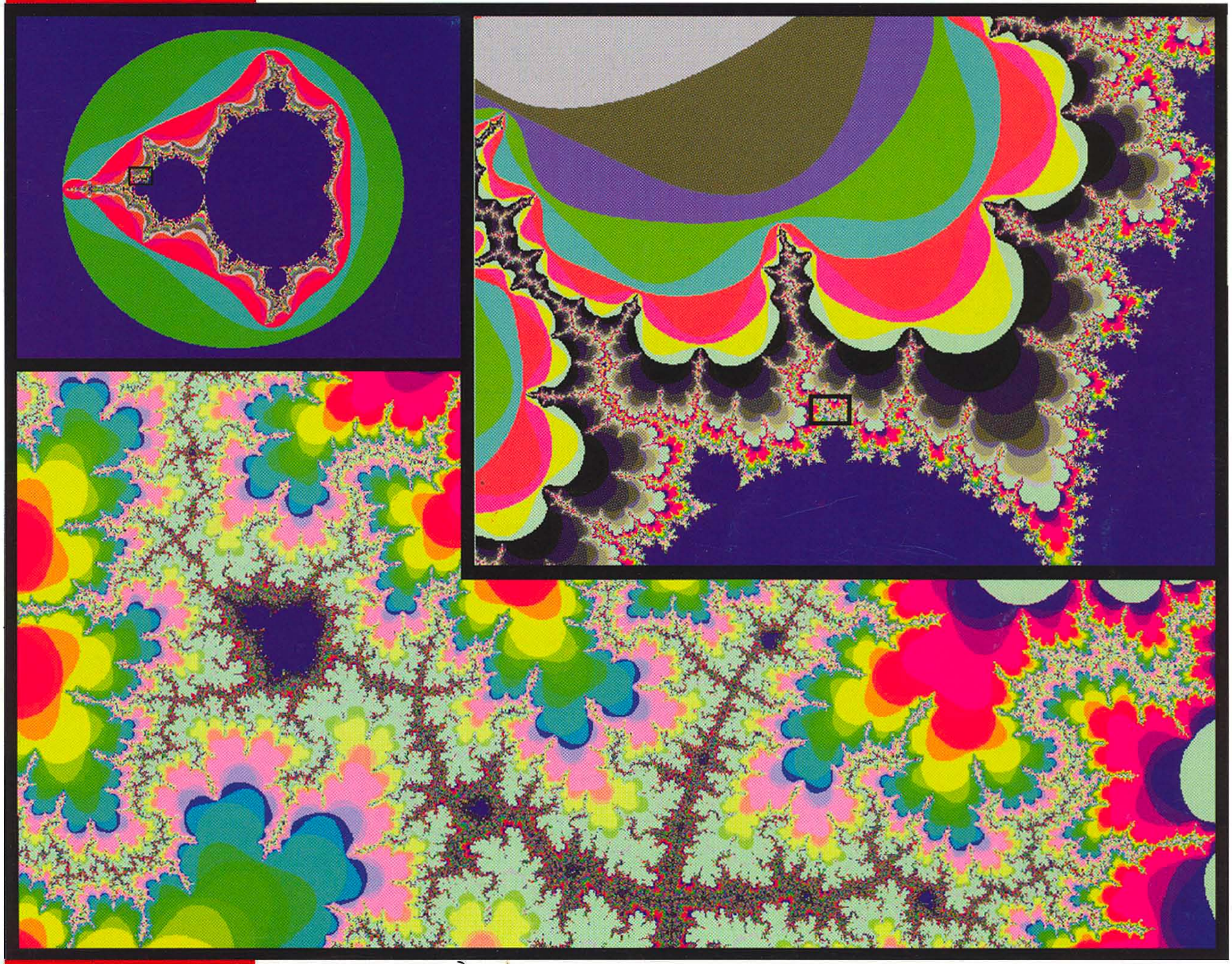

In this issue:

Chaos Theory: Uses and Abuses

The Bible and Chronology 2

Jacob's Experiments in Goat Genetics

Oil Formation and Exploration

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Vol. 7 No. 19
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Writing for Origins

Origins is looking for talented new writers, particularly those who have had experience in a specialised field of science or theology, in relation to creation, and who are in agreement with the aims and basis of the BCS. In addition, writers in a popular vein are needed, but accuracy and solid content are still essential. Any manuscripts for consideration should ideally be typed, double-spaced and sent to the Editor. Notes of guidance to authors are available on request. News items that may be of interest are also sought. We now welcome articles on disk in most formats, but 3½″ HD, Wordperfect 5.1 or ASCII preferred; media will be returned after transfer of the file.

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Whilst **Origins** exists to further the aims of the Biblical Creation Society, opinions expressed in articles and signed editorials are not necessarily shared by either the Editorial Committee or the Society.

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Editorial

WE HAVE often pointed out, particularly at our meetings, that the issue on 'origins' is more closely related to the court scene than to a purely scientific arena. One of the big problems is that we cannot go back to the initial moment of creation and so be sure, scientifically, of what happened. A lot of experimental work is carried out to find a way in which life could have originated and different types of animals and plants could have evolved from ancestral forms. *Even if these experiments succeeded*, it would not prove that life evolved in the way described by that experiment. At best, it would only demonstrate that the chosen method was feasible.

In the law court, forensic science seeks to achieve the same target concerning a past crime. What is the result? The defence and prosecution witnesses will seek to show that the evidence can be interpreted in different ways. Indeed, recent criminal trials have demonstrated the uncertainty in forensic science. This was recently underlined in a Channel 4 programme, *Incredible Evidence.*

The programme showed how our most trusted evidence has been shown to be unreliable. The presenter began by commenting, 'We all believe, judges, barristers and members of the jury alike, that science can lift the veil of uncertainty and deliver the truth. It is a dangerous illusion.'

After presenting the evidence, he concluded, 'We imagine that science can deliver a level of certainty we do not think applies to any other form of evidence. But, although a powerful story about the world, perhaps the most powerful, science remains a version of events; it is not reality.'

'Science doesn't deliver the truth; science simply gives us information that can be used along with other evidence in the case. The jury is supposed to make up their mind based on all the evidence in the case. Not just the scientific evidence.'

'Until we all come to terms with the fact that science does not deliver the truth, innocent people may continue to go jail.' We believe that, in the context of *origins*, the potential damage is greater. The theory of evolution misleads people and their eternal destiny is at stake.

In a trial, of course, the key evidence is that of trustworthy and reliable witnesses. Two such witnesses agreeing in their testimony present a powerful weapon. It is our belief that the Bible is God's testimony and we know He cannot lie. That is why we believe in the doctrine of Creation.

There was a fascinating insight into the anti-creationist mind in the *New Scientist* (25 February 1995, p.41). Roy Herbert was reviewing an Australian book, *Telling lies for God*, by geology professor Ian Plimer. The reviewer comments that on every page the author has something striking to say and quotes as an example: 'If creation "science" is correct, geologists must ask why God has written one enormous and superfluous lie in the rocks.' When will these people listen to what we actually say? Disturbingly, the Anglican Archbishop of Brisbane writes the foreword to the book!

With this issue we welcome some new members enrolled at the F.I.E.C. Caister Conference this year (1995). The Bible Studies led by Dr. James Montgomery Boice are a particular memory as he considered the theme of the conference: *'Restoring the Masterpiece: The image made, the image marred.'* Many were impressed again with the importance of the Genesis account of the Creation and the Fall to a right understanding of man, his nature, fall and salvation. (The tapes of these studies are available from the F.I.E.C. offices, 3 Church Road, Croydon, CR0 1SG). Next year the speaker at the morning sessions is our good friend from 'down under', Ken Ham.

A few years ago my wife and I were on holiday at Lugano in Switzerland. Holidays are a time for me to catch up on my reading. One of the books I had chosen for that holiday was *Chaos* by James Gleick (Cardinal, Penguin, London). It must have been amusing to hear me, as I sat reading beside the lake, repeatedly making exclamations of wonder at the work of God as I read this book. So often the marvellous nature and beauty of the applied mathematics of this subject filled me with wonder. I discovered from it a new fundamental constant. The increasing level of detail in fractals was staggering. I was filled again with praise of our incredible Creator. You can imagine my suprise as I came down to earth only to discover that the evolutionists were claiming this as the answer to their problems!

In this issue we have part 1 (of two parts) of a long-awaited article by Peter Senior on *Chaos and Complexity.* I believe this is essential reading for anyone wanting to confront evolutionists at the sharp end of the debate.

Many must wish that they could be called from this earth into the Lord's presence whilst they are serving Him. Obviously *in whatever we do, we do all to the glory of God.* However, the preacher dreams that he will be preaching of the Lord at that moment. Indeed, a good friend of mine was called by his Lord last year, just as he finished preaching and appealing to his congregation.

I was interested to read the story of Dr. Richard Bliss in the USA recently. He had been speaking on creation in Robins, Iowa. He concluded, 'I want to tell you in my testimony today, dear friends, I want my banner to be clear should Jesus Christ call for me today. I want Him to see Dick Bliss and I want my banner to be clear. How about your banner?'

The service ended and after lunch he turned aside to prepare for his evening engagement. Later, inside his room, the pastor found that the Lord had called Dick. His banner was clear. He stood for the Lord Jesus Christ and sought, over many years, to faithfully preach the word of God, especially in the matter of Creation. We have no doubt that he was greeted with 'Well done, good and faithful servant.'

It is our desire in the Biblical Creation Society to be faithful to Him. This year we celebrate our twentieth anniversary and our next issue of *Origins* will reflect that. Whether we have been faithful is for the Lord to judge. We have found Him to be faithful and continually rejoice in His goodness.

JHJP

Layman's Summaries

In response to suggestions from some members, we are including a summary of each article so that readers can be acquainted with the contents of each main article in terms understandable to the non-specialist.

Chaos theory

Most people meet this theory through attractive figures such as those on the cover of this issue. Recent research about natural processes and features shows that many of them do not follow simple relationships suggested by our classical scientific equations. Often it is only a few factors combining together in a complex manner which it is difficult to represent in simple relationships.

Recent evolutionary writers suggest that it is out of these unstable, chaotic systems that life could arise. Such beliefs arise from a misunderstanding of the principles involved. In the first of a two-part series, Peter Senior draws on his own research experience to help us understand the principles underlying the subject.

Goat genetics

Ewan More is a new writer to the Creation scene and promises to provide us with more articles analyzing evolutionary thinking. In this paper, however, he shows that the Bible story of Jacob and the goats can be understood by following some very basic genetic rules. Obviously Ewan does not discount any divine intervention in the process, but shows that the principle described in the Scriptures does have a good biological base.

Oil formation

Many creationists get tired of the accusation that our young earth position is not consistent with the formation and discovery of oil. To the best of our knowledge, no-one involved in oil exploration ever thinks in evolutionary terms. Paul Garner has written an article which demonstrates that this link is not factual or reasonable. Readers will find this article informative and probably discover some surprising facts, such as the age of oil deposits.

Bible chronology

In the last issue, John Peet emphasised the reliability of the Scriptural records on chronological matters. If that thesis is accepted, what can we deduce about the dates of Creation and the Flood, key events in the *biblical creation* position? Do the biblical data give us reason to believe in a young earth or is an old earth possible? A *scientific creation* option does not need to take the biblical data seriously. It would be based on scientific discovery rather than biblical revelation. But, for a society claiming to be a *biblical creation society* we need to be clear on this.

This article takes us through the biblical data back to the time of the patriarchs, then into the early chapters of Genesis. The author also, and necessarily, evaluates the completeness of the genealogical tables. Within the limits on genealogical data described, the biblical data indicates Creation to be about 6300 years ago and the Flood to be at about 2500 BC. Future articles will test this reconstruction against archæological and geological data.

JOURNAL ALERT

A new resource for members of the

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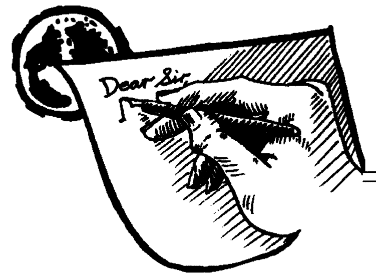


Correspondence

John Corcoran

The Times newspaper wrote, on 20 July 1994, 'Twenty five years after the first landing of human beings on the moon, many mysteries remain about it. We still do not know ... whether it has a molten core.'

In the Bible, we read, 'In order to explain the events that the people in Jerusalem were seeing, Peter stood up ... and addressed the crowd: 'This is what was spoken by the prophet Joel: 'In the last days, God says, I will pour out My Spirit on all people ... I will show wonders in the heaven above ... The sun will be turned to darkness and the moon to blood.'"' (Acts 2:4)

Peter is referring to events of the last two months after the death and resurrection of Jesus Christ in approximately 33AD. He quotes another biblical writer, Joel, who wrote an estimated 700 years previously, when I suspect, he witnessed similar solar and lunar events. But, here Peter is referring to events of his own time, 'the pouring out of God's Spirit' which is the subject of his talk. He mentions 'the sun turned to darkness' which had happened a few weeks before at Christ's death: 'darkness came over the whole land ... the sun stopped shining' (Luke 23:44). (Here it was observed by a different writer). Peter also mentions that 'the moon has turned to blood.' (I would assume some of the moon but not all of it).

Peter could be referring to an atmospheric event that has made the moon look unusually red (Acts 2:19). 'Signs on the earth ... fire and billows of smoke' implies that he also knows of volcanic activity at the time, perhaps a minor eruption of Vesuvius in Italy, a week's sail journey away. Dust from this would redden the sky, but it would also turn the stars and sun red, which Peter does not mention.

A second possibility of the moon turning red would be if it was showered with red dust in space, in which case it should still be there somewhere on the moon.

A third possibility is that (about 33 AD) enough red molten rock was flowing on the moon for it to be visible to the earth. Peter is living through momentous times. He is referring to monumental events and he is struck by the uniqueness of these incidents, so much so that his reference is to Joel where a similar event seems to have happened some 700 years previously. This rules out the possibility of it being just an atmospheric effect from a terrestrial volcano because these occur more frequently than every 700 years.

It seems that Peter is describing the third of these possibilities, although all three may be contributing factors.

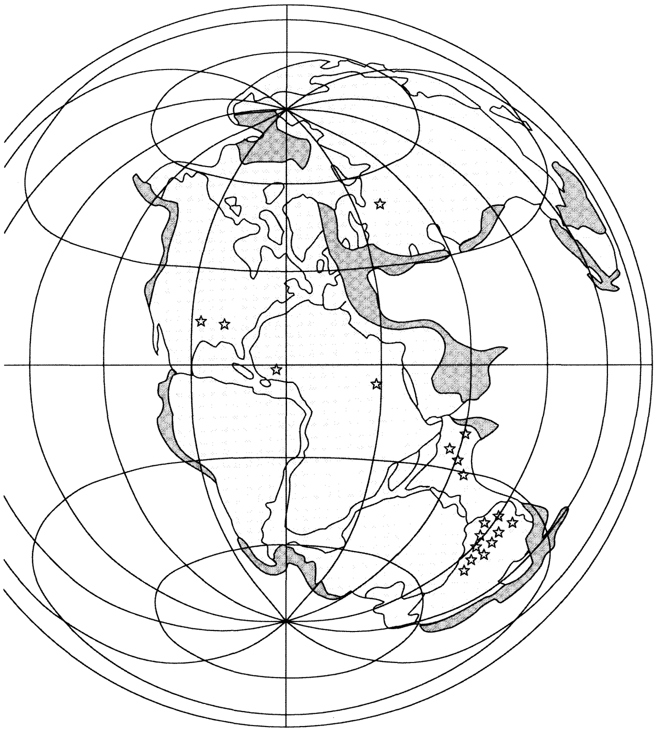
Remains of molten rock on the moon means it came from somewhere else, or something hit it at high speed and melted, or it flowed out of the lunar core. The melting of rock caused by a meteorite would be a short-lived event. The 'turning to blood' points to a steady stream of molten lava flowing from fissures or craters on the lunar surface (although meteorites may have triggered some of this). There are few (about 18) human and machine lunar exploration sites with a maximum depth of a half metre. The composition of some collected rocks approaches that of some of the earth's dark igneous rocks (from which period of moltenness is not known). Therefore, the moon bears some rocks that were molten only 2,000 years ago (which rocks are yet to be determined). Also, the lunar core is still molten.

Furthermore, John says, 'the whole moon [will again] turn blood red' (flow of molten lava) at some future time of catastrophe (Revelation 6:12).

James H Peet

With reference to the valuable, informative article on Tektites (*Origins*, 1994, 7(17)), I would suggest an additional comment. The attached map. which is based on a non-creationist model—without accepting the time-scale given—may well be a reasonably accurate pattern of the surface of the dry land before the Flood. This could mean that the tektites arrived before the continental drift was far effected (Genesis 10:25).

I have imposed on this pre-drift map the sites of the tektite occurrences shown in the article. It will be seen that the sites are not as disparate and scattered as they appear on a modern map. They lie in a broad, straight band from Australia to North America. This suggests that the object of their origin could have struck Australia (hence the great quantity there) and sprayed (as water from a garden hose) or bounced (as a ball from a bowler) in a straight line across the globe. The amounts fall as the quantity remaining decreases.



The implications of this, especially as it relates to the Scriptural record, I leave to those more qualified to assess. [*Editors:* we suspect that Mr. Peet may have confused India and Indo-China in the diagram supplied, but the concept described is an interesting one.]

Esme Geering

I have been very interested in your article on Bible chronology in *Origins.* I was brought up ... to believe every word of the Bible so I never swallowed evolution in school science courses, but I did find the ages of the patriarchs a problem. I made a chart ... from Genesis 5 and 11 and other verses. I got to the end of Joshua. I found that Noah's father was contemporary with Adam and Noah with Abraham. I have just read the Book of Jasher which says that Isaac sent Jacob to Shem and Eber (still alive) to be taught of the Lord, but Esau would not go.

I got stuck with Joshua so I got an ordinary history book and put in the fall of Nineveh and Jerusalem and worked backwards with the reigns of the kings to the Judges and found the lines met. It meant leaving no room for missing people ... I went on to the Accession of Queen Elizabeth. We have these in four sections in black and white for £1 if anyone is interested.

[*Editors:* Esme sent one for us to examine. It is very attractive and informative. While it does not coincide exactly with the reconstruction in the second part of the series, in this issue, it does parallel our work very closely. Esme can be contacted at: 17 Thomas Street, Tunbridge Wells, TN4 9RN].

Dr. Glen Zweck

[*Editors:* Because of its length and detailed footnotes, this letter has been edited—hopefully without removing its arguments. A copy of the original can be obtained on request to the editor. A reply to these points is not given at this stage as some will be covered in subsequent parts and some are acceptable points of differing opinion.]

I agree with J. H. John Peet (*Origins*, 7(18)) that the Book of Genesis is presented in historical form and context. However, there are some inaccuracies in his article.

In the first place, Mark 2:26 [Mark 6:26 is a misprint] does not say, 'when Abiathar was high priest,' even if many English mistranslations assert that it does. A more accurate translation would be, 'in the time of Abiathar the high priest' (Arndt and Gingrich, 1957, p.286).

When the incident recorded in 1 Samuel 21:1–6 took place, Abiathar was probably present [1 Samuel 22:10], but it was his father, Ahimelech, who was high priest. Abiathar became high priest shortly afterwards, when King Saul had his father, Ahimelech, together with the rest of the priests at Nob, killed by Doeg the Edomite [1 Samuel 22:18–19].

The question that arises is: Why does Jesus mention Abiathar, rather than his father Ahimelech? The obvious answer is, that He believed that would strengthen the case He was arguing.

The Pharisees had charged Jesus with the sin of permitting His disciples to break the sabbath command, because they plucked ears of grain on the sabbath day, to ease their hunger. Jesus rebutted their charge, by citing a case from the Old Testament. In this case, Ahimelech the high priest had decided that a different ceremonial law (not the law concerning the sabbath, but the law concerning the eating of the weekly showbread) should yield to the law of love, and might thus be broken without sin.

Peet's following statement, with reference to the genealogical data of Genesis, is strange: 'Indeed, one might well ask what significance there was to this data if it were not meant to be chronological'. There are a number of things that can usefully be derived from this genealogical data, but a precise chronology is not one of them.

Peet himself draws attention to the thematic nature of the 'Toledoth' statements in Genesis [Genesis 2:4; 5:1; 6:9; 10:1, 32; 11:10, 27; 25:12, 13, 19; 36:1, 9; 37:2]. He sees in them a tracing of what he calls 'the covenant line'. A better title would be 'the line of the promised Saviour'. Note how this data is used by St. Matthew [Matthew 1:1–17] and St. Luke [Luke 3:23–38] to support the teaching of the true humanity of Jesus Christ.

Note how Genesis 5 reports the age at which a man became the ancestor of the next in line, incidentally defining a generation with reference to the ancestor [compare Genesis 15:16 and Genesis 21:5 and 12 with Exodus 12:40–41 and Acts 7:6], and his age at death. The repetition of 'then he died' emphasizes the reality of the death as the consequence of the transgression of the law.

Note the sharp reduction that these data reveal in the human life-span after the Flood. A consequence of this was the removal of a major check on the reliability of oral tradition. Hence the need for Moses to begin the writing of the Scriptures.

However, note particularly that the genealogical lists of the Old Testament lack precisely that information which is most necessary for the construction of a precise chronology, namely they lack a summary addition, at the end of the list. Contrast this, for example, with the twofold summaries (first by tribes [Numbers 1:46], then by camps [Numbers 2:32]) of figures that are provided, as a check on the accuracy of the figures of the census in Numbers 1 and 2.

Note also, that Scripture is perfectly happy to omit names from genealogical lists, for a variety of reasons, without making any apology for doing so. Compare, for example Genesis 11:10–18 with Luke 3:36, or 2 Kings 22:1 with Matthew 1:11, or Exodus 6:16–20 with 1 Chronicles 7:23–27.

Chronology is one of the least obvious suggestions for the genealogical data supplied in Scripture. At best, this data provides us with a minimum chronology. By implication, it also points to thousands of years of human

Continued on page 29

Reviews

Creation and Time: A Report on the Progressive Creationist Book, by Hugh Ross. Paul Taylor and Mark van Bebber. Eden Productions (2628 West Birchwood Circle, Mesa, Arizona 85202, USA) 128 pp. £4·50. ISBN 1-877775-02-9

Reviewed by David C. C. Watson

THIS is an important book. Ross is a popular Bible teacher who has persuaded many to adopt what he calls 'progressive creationism', including (1) the Big Bang really happened, (2) death and bloodshed existed for millions of years before Adam, (3) the Flood was local, not global, (4) the early Fathers believed in 'long' creation-days. The authors carefully examine these claims (47 in all) and refute them one-by-one, in the light of Scripture, church history and common sense.

The book is a scholarly appraisal of the evidence, well researched and well documented, with a good index and bibliography. It will be invaluable to Christian ministers who linger hovering on the brink of theistic evolution but fear to launch away into a straightforward interpretation of Genesis.

Copies may be obtained from the Creation Science Foundation (UK).

[*Editors:* Another review of this book will be included in Issue 20.]

Why I believe in Creation, by Dr. Monty White. Published by Evangelical Press (24 pages) Price $1·95. ISBN 0–85234–319–1

Reviewed by Tony Rummery

THIS book, which is in a magazine format, sets out with two aims: one of explaining why the author believes in Special Creation and the second to demonstrate that belief in the Biblical account of Creation is reasonable, rational and scientific. The author reminds us of the breadth of scientific discipline required to debate this issue and of the difficulty of writing a brief but sufficiently extensive survey of the subject, but he maintains a good balance between the aims of brevity and adequate handling of the issues throughout.

Having dealt briefly and helpfully with the theological issues as to why belief in Special Creation is vital for the professing Christian, he then takes the reader through various evidences to its truth from a scientist's standpoint.

The first chapter deals with the so-called Big Bang theory and the origin of the Universe. Subsequent chapters deal with plant, animal and human origins and the fossil record. The last chapter deals with the age of the earth. It is therefore a comprehensive although not exhaustive survey of the creation/evolution debate. It is especially useful for a general reader who lacks in-depth scientific knowledge as well as for the young person grappling with evolutionist propaganda at school or college.

The issues are fairly presented but the reader is left in no doubt as to the robust pro-Creationist stance that the author takes. A short Gospel passage at the end of this publication makes it usable in personal witness, as well as reminding us that the ultimate goal of Biblical Creationism is the defence of the historic Gospel 'once delivered to the saints' (Jude 3).

I am very pleased that this book is available: it helps to fill the gap in literature of sufficient detail, but is nonetheless suitable for the layman in scientific matters.

In a book of this size it has not been possible to cover all aspects of origins, such as the Flood for example, so I hope in future other areas which were not able to be included in this publication will be able to be covered in a similar way.

Prehistory: A Time to Throw Away, 82pp £4·00. ISBN 1-899654-01-1
Thinking about the Six Days of Creation, 54pp £4·00. ISBN 1-899654-02-X
Fossil Men Reconsidered, 33pp £3·50. ISBN 1-899654-00-3
Gerald Duffett, Welsh Riviera Press (The Forge, New Hedges, Tenby, Dyfed. SA70 8TL), 1994.

Reviewed by David C. C. Watson

HERE is a trilogy of apologetics which will be useful to Christian teachers of science and RE. The author is a retired Head of Biology, a convinced creationist, who has published articles on *Archæopteryx* feathers, 'ape men' and related topics in learned journals.

These books, by contrast, are designed for schools and he generously allows any teacher who buys one to copy or reproduce the worksheets and/or pages from the text. (The page size is A4 and printed in large bold type).

Of the three, the *Prehistory* book is perhaps he most original, covering a wide range of subjects—from astronomy and the Grand Canyon to DNA and dinosaurs. The author's method is discursive: there are no references and only a few diagrams, but the total impact of creation evidence from so many branches of science is considerable.

Flashes of humour, sidelights on history and startling analogies make the books highly readable ... even if some of the questions in *Six Days* are unanswerable (*e.g.* 'Why were there only two main lights?'). They will make teenagers think. As a counterpoise to these uncertainties, the commentary on each Day is followed by firm conclusions—of which the firmest is that God means what He says. *Fossil Men* does have references, 76 of them, mostly to books by non-creationists, and 44 questions on worksheets. By these, Duffett contrives to make a boring sideline interesting. Piltdown and Nebraska Man *et al.* receive their fair share of ridicule.

All in all, we strongly recommend this series for the classroom. For detailed studies, the teacher will need other books, but we know of no better introduction to the grand question of all education: 'Does Science contradict Scripture?'

The Bible and Chronology

2: The Biblical Framework

J. H. John Peet

THE BIBLE claims to be historical in its presentation of the record of God's intervention in this world. This is applicable both at Creation and in His controlling of the earth's ongoing existence (Peet, 1994). But, the Bible was not written in a twentieth century Western civilisation, but over a period of several centuries in the Middle East. A cursory inspection of most major museums will demonstrate that the Middle East[1] had a different way of describing history. To correctly understand the Scriptures, we must recognize these differences.

A number of key questions must be tackled before we go on to convert the biblical data into a time chart. With few exceptions, periods of time are always represented as a number of years. What we do not know is how the chroniclers dealt with fractional years. Over a large number of generations these fractional years could make a significant difference in detail though not in principle. Any data given in this paper should be interpreted in this light.

The old problem of interpreting the regnal data in the books of the Kings and Chronicles has been tackled very adequately by a number of writers. The best known is the work of Thiele (1977; 1983). Another writer (Faulstich, 1986) has worked on a computer programme to reconstruct the data in step with the Sabbath and Jubilee Year records, also based on moon phases, vernal equinoxes, priestly cycles, *etc.*

Thiele has shown that there are different ways of reckoning the start of the reign and also of allowing for coregencies[2]. These differences can be demonstrated with some 'modern' analogues. For example, we all think of this year as 1995, or do we? This date is 'in the Christian era'. For a Muslim, it is 1415. For a Jew, it is 5756. So, we need to know the calendar system being used. It would seem to have varied between Israel and Judah. Closely related to this is the variation that can arise from the new year dating. In the West, we date our year from 1st January. For the Jew, it starts in September. Figure 1 shows the relative details. In the Old Testament, Israel's year begins in Nisan (spring) and Judah's in Tishri (autumn).

The regnal year can be counted as from the moment of accession or coronation. So, Queen Elizabeth II can be reckoned as reigning for 42 or 43 years on this basis (see Figure 2). The Queen acceded in 1952, so her reign can be counted from that year or from the coronation in the next year, or, even, from January 1st in her first full year. Israel followed the accession year system, but Judah from the first full calendar year.

With coregencies, we see a number of examples in Scripture. Tibni and Omri had parallel reigns for a time (1 Kings 16:21). These were rare in Israel because of the frequent usurpations that occurred. In Judah, coregencies were more frequent. One example is that between Jehoram and Jehoshaphat (2 Kings 8:16–17). Events dated to the reign of Jehoram can be dated from the beginning of his coregency or from the date of his sole reign. The same principle seems to apply in our interpretation of the times of the Judges (Peet, 1982–3).

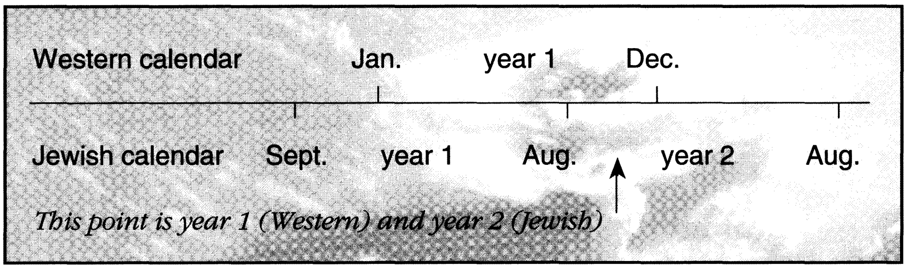


Fig. 1: Western and Jewish years

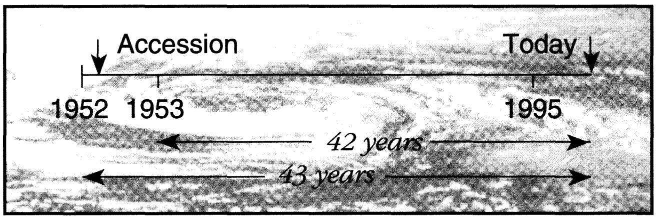


Fig. 2: Regnal dates

The Genealogies

One of the characteristics of the Jewish record was the detailed tabulation of their family trees. Yet, if studied too superficially, they can be misleading. This is not to say that they were in error—they were not. Rather, we need to understand the process of thinking behind them. A clear example is given in the genealogical tables of Matthew 1 and Luke 3. There is a difference in the number of

Battle of Qarqar (Ahab)	853
Jehu's tribute (Black Obelisk)	841
Stela from Rimah	796 (approx.)
Menahem's tribute	738 (approx.)
Hoshea replacing Pekahiah	734 (approx.)
Ahaz in Judah (Nimrud Slab)	734 (approx.)
Capture of Samaria	722/721
Subjugation of Judah	715
Siege and capture of Lachish	701
Manasseh's tribute	676 (approx.)
Fall of Nineveh	612

Table I: Some Assyrian chronological links.

Jehoiakim's submission and Daniel's capture	605
Battle of Carchemish and the 4th of Jehoiakim	605
Fall of Jerusalem and capture of Jehoiachin	597
Jehoiachin's rations	between 595–570
Destruction of Jerusalem	587
Deportation	581
Death of Belshazzar	539

Table II: Some Babylonian chronological links

generations[3]. In Luke, we have forty-two generations from David to Jesus Christ; Matthew has twenty-seven. A similar 'problem' arises in the genealogy of Moses.

The ancestry of Moses is given as

Jacob—Levi—Kohath—Amram—Moses

That would be consistent with a relatively short period of exile in Egypt, certainly too short for the 430 years mentioned in Exodus 12:40. A comparison with the genealogy of Heman (1 Chronicles 6:33–38) makes it clear that the corresponding tree for Elkanah, Moses's contemporary is

Jacob—Levi—Kohath—Izhar—Korah—Ebiasaph—
Assir—Tahath—Zephaniah—Azariah—Joel—Elkanah

This would be consistent with the chronological data. Similarly, Joshua is the twelfth generation (1 Chronicles 7:23–27), yet Bezaleel is apparently the seventh (1 Chronicles 2:18–19; Exodus 35:30). So, there are 'missing' generations in Moses's line. This flexibility in presenting the details is consistent with various aspects of Jewish thinking. Unimportant names can be omitted. Names may be passed over to give a symmetrical pattern (*e.g.* multiples of seven, as in Matthew 1). Numerical patterns can have greater significance to the Jewish mind than individual names. The arrangements reflect the purpose of the genealogy[4]. Similarly, Joshua is the 12th generation (1 Chronicles 7:23–27), yet Bezaleel is apparently the 7th generation (1 Chronicles 2:18–19; Exodus 35:30).

So, when using genealogies to fix chronologies, we must bear such implications in mind. However, this does not allow us to stretch such genealogies indefinitely. Certainly in the post-Abrahamic period there are sufficient counter-checks in the Scriptures for us to identify when the family trees are abbreviated. I believe that controlling information is available in the other periods too.

The genealogies of Genesis 5 and 11 are of particular significance. There is a symmetry (ten generations ending in three sons), suggesting that symmetry is more important than completeness. However, there is no evidence that there *are* missing generations. Jude 14 does identify Enoch as the seventh from Adam. There is also a lot of detailed data on the ages (*e.g.* Genesis 5:6–8); they must have some significance!

A strict interpretation has the deaths of Lamech and Methuselah in the year of the coming of the Flood. Allis finds this to be a 'startling conjecture'. But why? If it were not a strict chronology, we would be more likely to find their life spans overlapping the Flood (in theory)! These early genealogies *may* be incomplete, but a substantive case has to be made. Clearly the biblical data, if complete, indicates a date for Creation of some six thousand years ago. The genealogies require that this event could not have been much prior to that.

One author (Camping, 1974) believes that the structure of Genesis 5 does imply generation gaps and can be constructed chronologically to give a date of about 11000 BC for Creation and 5000 BC for the Flood.

Length of Babylonian exile	70 years	Daniel 9:2; Jeremiah 25:12
Wilderness wanderings	40 years	Numbers 14:34; Acts 13:18
Exodus to fourth year of Solomon's reign	480 years	1 Kings 6:1
Rule by the judges	450 years	Acts 13:20
From occupation of east of Jordan to Ammonite attack	300 years	Judges 11:26
Affliction of Abraham's descendants[6]	400 years	Genesis 15:13; Acts 7:6–7
Descent of Jacob into Egypt to the exodus	430 years	Exodus 12:40

Table III: Some biblical chronological data.

Constructing an absolute chronology

(a) The external correlations

Bickerman (1980) describes how the chronology of the ancient world is established and this is a helpful background. It is our desire to relate Jewish history to this absolute chronology of the ancient world.

To Bible students there is some frustration arising from the attitude of many scholars. The Bible is relegated to a second (or third) class record against such as the Assyrian chronology. It should be noted that the biblical history is much more extensive in chronological terms. This should be the basis of our interpretation of the ancient world and will be reviewed in the next part of this series.

The links between biblical events and the 'outside' world are extensive (Thomas, 1958). For example, Nebuchadnezzar's attack on Jerusalem is related to the reign of Jehoiakim (2 Chronicles 36:5–8). We also have references to Assyria (*e.g.* Sennacherib, 2 Kings 18:13) and to Egypt (*e.g.* Necho, Jeremiah 46:2). See Table I (for further Assyrian links) and Table II (for Babylonian links). Egyptian history is less precise and so less useful for chronological purposes.[5]

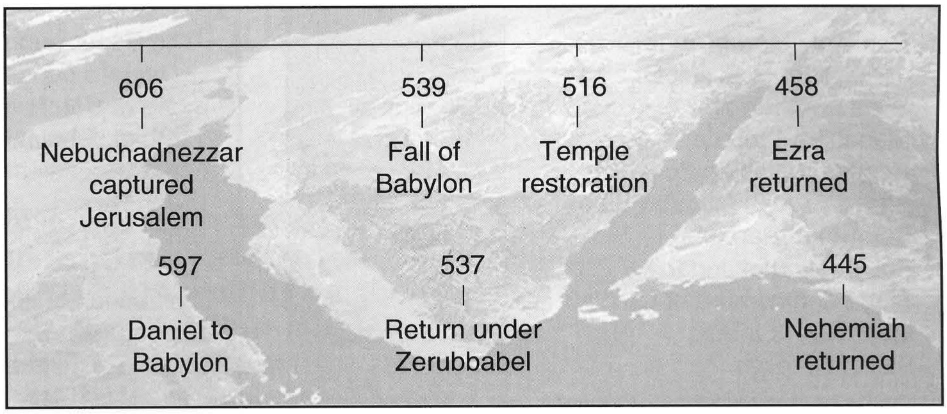


Fig. 3: The exile and return

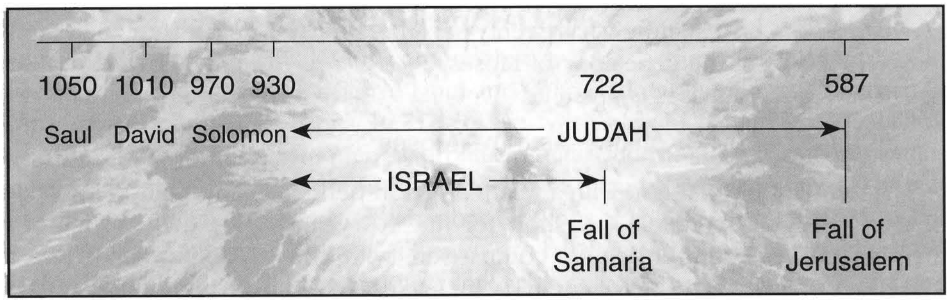


Fig. 4: The monarchy

Name	Age at birth of firstborn (years)	Approximate date of birth (BC)	Age at death (years)
Jacob		2005	147 (Genesis 47:28)
Isaac	60 (Genesis 25:26)	2065	180 (Genesis 35:28)
Abram	100 (Genesis 21:5)	2165	175 (Genesis 25:7)
Terah	70 (Genesis 11:26)	2295[11]	205 (Genesis 11:32)

Table IV: The Patriarchs

There are some problems in seeking correlations. People can be identified by different names in different countries and so it can be difficult to identify specific links. Even when we have that information to hand (*e.g.* the Hebrew and Babylonian names of Daniel and his friends, the Hebrew and Egyptian names of Joseph), we may have insufficient extra-biblical records to find them.

(b) The internal correlations

There is some useful chronological data to include in our reconstruction of the biblical history. Table III summarises this. Our reconstruction must be consistent with this data.

Construction of a chronological table

We will seek to use these principles to produce a time chart for Old Testament history. There is no attempt here to fill in all the details. We seek a basic structure. The *Biblical Creation Society* does publish a literature guide to aid subscribers to pursue this matter (Bimson, 1990).

Tables I and II include key dates derived from conventional history of the non-Jewish nations. One useful date is that of the death of Belshazzar (539 BC). Since the exile was for seventy years and the return under Zerubbabel was in 537/6 BC (Ezra 3), Nebuchadnezzar's conquest of Jerusalem must have been in 606/5 BC. This is the third year of Jehoiakim.

(a) The period from the exile

Following the return, the Temple was rebuilt and dedicated in the sixth year of Darius (516 BC; Ezra 6:15). Nehemiah rebuilt the walls, starting in the twentieth year of Ataxerxes (445 BC; Nehemiah 2:1). Figure 3 summarises this information.

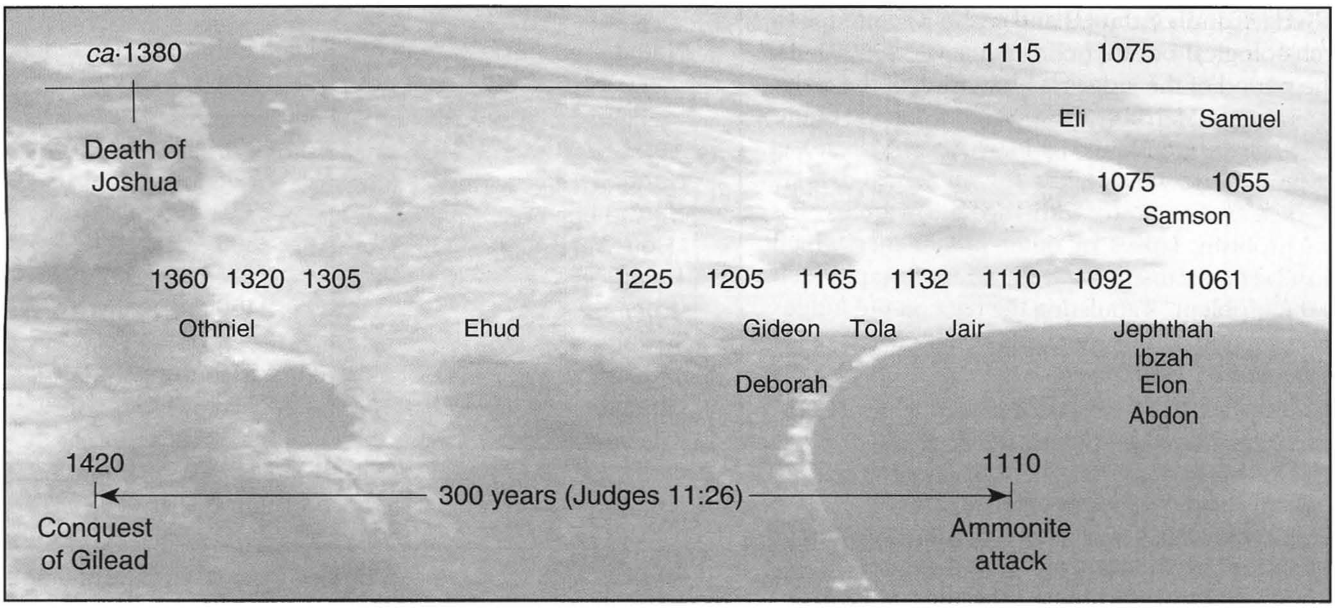


Fig. 5: Summary

(b) The period of the monarchy

This period can be fixed through the chronological data of the kings, as referred to earlier in this article. There are a number of checks by cross-reference to the external data (see again Tables I and II). Further detail is found in, for example, the attack of Sennacherib on Hezekiah (701 BC) which is related to the fourteenth year of that king (2 Kings 18:13). Proceeding through the biblical data, we can date the division of the kingdom to 931/930 BC. The first three kings of Israel each reigned for forty years (Acts 13:21; 1 Kings 2:11; 2 Chronicles 9:30). There is an indication of a possible short coregency between David and Solomon (1 Chronicles 28:5).

(c) From the Exodus to the Judges

This is a critical period in the reconstruction of Hebrew chronology. It is in this time that the greatest debates occur, even among the evangelical scholars. For example, UK scholars (*e.g.* Kitchen, 1980) tend to favour a 'late Exodus' (dated around 1250 BC) whereas their American counterparts and some British scholars (Aling, 1981; Bimson, 1978) favour an 'early Exodus' (set at around 1450 BC)[7]. The archæological problems (to be discussed in the next issue of *Origins*) centre around this dating problem too. In keeping with *BCS* principles, I align myself with those who determine their reconstruction primarily from the Scriptures.

There were 480 years from the Exodus to the fourth year of Solomon's reign (1 Kings 6:1). This puts the Exodus at around 1450 BC (see Figure 4 on the monarchy)[8]. So, in the period from the Exodus to the beginning of the monarchy, we have 400 years to cover the period in the wilderness (forty years), the conquest and rule of Joshua and the time of the Judges[9].

Figure 5 summarises this period. As will be apparent, there is some overlap between the judges. The diagram is reconstructed entirely from the biblical data (in the book

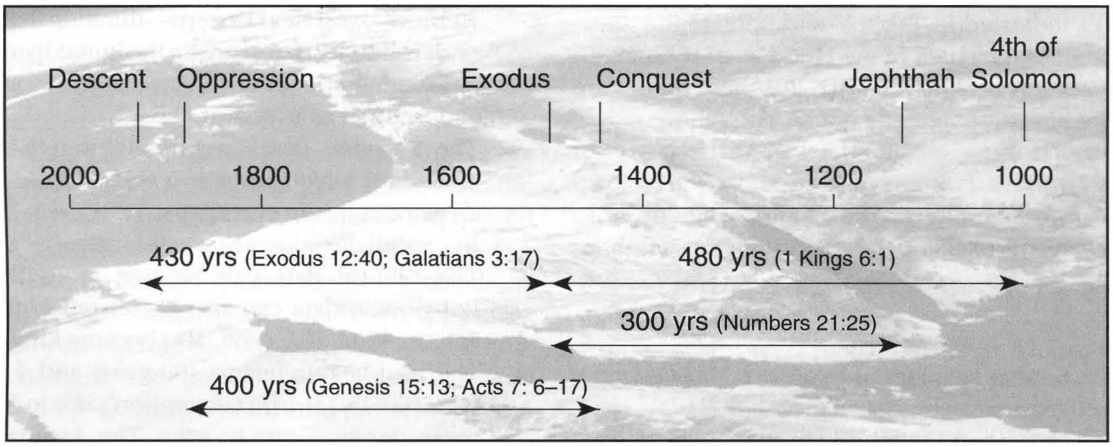


Fig. 6: Integrated data

of Judges and 1 Samuel) and without reference to archæological or other constraints (Peet, 1982–3). The period of the judges is, therefore, of the order of 350 years. Merrill (1981) proposes that the figure of 450 years, mentioned by Paul (Acts 13:18–20), is a round figure which takes 'the numerical data ... at face value and with no allowances for synchronism, lapses or other possibilities which must be entertained in a truly 'scientific' approach to the problem.' Tabulating the data on the Judges gives a figure of 447 years, that is, 'about 450 years' as quoted by Paul.

(e) The Time of the Patriarchs

From Exodus 12:40, we learn that there were 430 years between the descent of Jacob into Egypt and the Exodus from the country. So the descent was around 1875 BC.[10] We can reconstitute the data for the patriarchs giving Jacob's date of birth at around 2005 BC (Bimson, 1980; Merrill, 1980; Peet, 1985). Jacob lived in Goshen for seventeen years and died at the age of 147 years (Genesis 47:28). He was, therefore born 130 years before the descent into Egypt. We can extend the data for the rest of the patriarchal period (Table IV).

We can now integrate a number of important pieces of biblical data[12] (see Figure 6).

Name	Age at birth of firstborn (years)	Date of birth (BC)	Total age (years)
Terah	70	2295	205
Nahor	29	2324	148
Serug	30	2354	230
Reu	32	2386	239
Peleg	30	2416	239
Eber	34	2450	464
Shelah	30	2480	433
Arphaxad	35	2515	438
Shem	100	2615	560

Table V: From Shem to Terah

Name	Age at birth of firstborn (years)	Date of birth (Early date)	Date of birth (Late date)	Total age (years)
Noah	500[16]	3248	3118	950
Lamech	182	3430	3300	777
Methuselah	187	3617	3487	969
Enoch	65	3682	3552	365
Jared	162	3844	3714	962
Mahalalel	65	3909	3779	895
Kenan	70	3979	3849	910
Enosh	90	4069	3939	905
Seth	105	4174	4044	912
Adam	130	4304	4174	930

Table VI: From Adam to Noah

(f) Back to Creation and the Flood

Moving back to the Flood (Genesis 11:10–26), we see it ended in 2518 BC (Table V and Genesis 11:10)[13, 14].

To calculate the approximate date of Creation, we can construct the Table VI from Genesis 5[15]. The Flood was in Noah's six hundredth year (Genesis 7:11; 9:28–29). The Table calculates the dates based on the two alternative chronologies indicated in Table V and note 13.

This data gives the dates of the Flood as 2518/2648 BC and of the Creation at 4174/4304 BC. *But*, these figures are subject to the limitations already noted. Though we would not demand that these specific dates are a necessity for orthodoxy, clearly it is impracticable and contrary to a reasonable understanding of the nature of Scripture to extend these events back much further than these figures.

Notes

1. The area known to many of us as the *Middle East* is described by archæologists as the *Near East.*
2. It is recommended that the amendment by Stigers (1967) be implemented.
3. There is a difference in content too—one through David's son, Nathan, and the other through Solomon. These are generally understood to represent the lines through Joseph (Matthew's account) and through Mary. Matthew is concerned with the legal, royal line, whereas Luke emphasises the blood line (*c.f.* Luke 1:34–35; 3:23).
4. The term 'son of ...' has a wider significance in Hebrew—and Near Eastern—thinking than in Western understanding. It may mean the immediate descendant or just 'descendant of ...' For example, our Lord Jesus is described as a 'son of David'.
5. The absolute dates are fixed through an Assyrian annual list which refers to a solar eclipse. Since this is an extremely rare event, it can be fixed to 15th June 763 BC. So, all the other years in this calendar can be dated. The biblical data can be tied in to this list. The Babylonian data can also be related to this list since Sargon, king of Assyria, also became king of Babylon.
6. The prophecy refers to 400 years and 4 generations (Genesis 15:13–16). 'Generation', *dôr* in Hebrew, can mean duration, age or span. The Assyrians used the word to represent 80 years or more; it is quite possible

that here it could represent a century (Albright, 1961; Bimson, 1978/1979).

7. One scholar (Rendsburg, 1992) has sought to harmonise the biblical account with archæology by proposing a twelfth century exodus. However, this can only be done by rejecting biblical chronology as mostly fictitious.
8. There is conflict between our reconstruction and that in the Babylonian Talmud or that by the Jewish historian, Josephus. The Talmud and later commentaries give the exodus as 430 years from Abram's departure from Ur and 400 years from the birth of Isaac. Josephus gives the 430 years from Abram's departure out of Haran and the 400 years from the weaning of Isaac. These data give either a 210 year period in Egypt (Talmud) or 215 years (Josephus).
9. The size of the population is consistent with the longer period, but not with the shorter one. We know that seventy people went into Egypt (Genesis 46:26–27; Exodus 1:5) and 600,000 men, plus women and children, left. This is consistent with the 430 years (Exodus 1:6–7; 12:37, 40–41). One reason some are sceptical about the size of the population is that it is difficult to envisage two million people camping around the traditional site of Sinai. A recent publication suggests that the site is wrong (Williams, 1990).
10. Joseph was 30 years old when he met Pharaoh (Genesis 41:46). Jacob entered Egypt after the seven years of plenty and some of the years of famine, say 10 years after Joseph became vizier. We have dated the descent to 1875 BC, so Joseph was born *ca.*1915 BC and died 1835 BC (Genesis 50:26). The oppression began at least a generation later—or in a new dynasty—under a pharaoh who did not know Joseph (Exodus 1:8; Acts 7:18). So, the oppression ran from *ca.*1800—1400 BC (Genesis 15:13; Acts 7:6–7).
11. Abram's dates: born 2165; left Haran 2090 (Genesis 12:4). Terah died *ca.*2090 (Genesis 11:24–25) and was born 2295 (Genesis 11:32). If Abram was born in 2165, Terah was about 130 years of age. Genesis 11:26 refers to the age at birth of the firstborn, possibly Haran who died while they were still in Ur. The listing starts with the key person in salvation history (*c.f.* Genesis 10:1, 21).
12. The prophecy to Abram (Genesis 15:13–14) clearly indicates that his descendants will be in Egypt for 400 years. Stephen indicates that this would have been a period of slavery and ill-treatment (Acts 7:6). God's promise to Abram that they would be released in the fourth generation (Genesis 15:16) could be interpreted to fit either the shorter or the longer period of captivity, but the context clearly equates the four generations with 400 years. Galatians 3:17 alludes to a promise made 430 years before the law was given. At the time of the descent, the promise was given to Jacob (Genesis 46:3–4). Paul says that the promise was not nullified by the law given 430 years later.
13. The Septuagint version includes another generation between Arphaxad and Shem, *viz.*

Name	Age at birth of firstborn (years)	Date of birth (BC)	Total age (years)
Shelah	30	2480	433
Cainan	130	2610	460
Arphaxad	35	2645	465
Shem	100	2745	560

    So, the Flood would end in 2648 BC. This is the data used in Luke 3:35–36. It is also in the Hebrew according to Genesis 10:24 (NIV footnote).

14. Robinson (1995) calculates the date of the Flood as 2458 BC from this data, presumably differing from me at note 11. However, he proposes a date of around 2850 BC for the Babel incident.
15. See Fetter (1956) and Sewell (1995) for a discussion of the relevant texts. The Septuagint does give variations in some of the ages and these push the dates back even further.
16. Shem was not the firstborn (Genesis 10:21) and so the age at which Noah became a father (Genesis 5:32) refers to the birth of the firstborn, Japheth. Clearly he and Shem were of similar age. But, note the alternative rendering of the first reference in the NIV.

References

Albright, W. F. (1961). *Bulletin of the American Schools for Oriental Research*, 163:50–51.

Aling, C. F. (1981), *Egypt and Bible History.* Baker, Grand Rapids, Michigan.

Allis, O. T. (n.d.), *The Five Books of Moses.* Presbyterian and Reformed Publishing Co., New Jersey. pp.295–298.

Bickerman, E. J. (1980), *Chronology of the Ancient World.* Thames and Hudson, London.

Bimson, J. J. (1978), *Redating the Exodus and Conquest.* J.S.O.T. Suppl. 5, University of Sheffield.

Bimson, J. J. (1978/1979), *A Chronology for the Middle Kingdom and Israel's Egyptian Bondage.* S.I.S. Review, 3(3):64–69.

Bimson, J. J. (1980), *Archæological Data and the Dating of the Patriarchs*, in Millard, A. R. and Wiseman, D. J., Essays in the Patriarchal Narratives. IVP, Leicester.

Bimson, J. J. ; revised Peet, J. H. J. (1990), *The Early History of Israel and Its Neighbours.* Biblical Creation Society, Rugby.

Camping, H. (1974), *Adam When?* Family Stations, Oakland, California.

Faulstich, E. W. (1986), *History, Harmony and the Hebrew Kings.* Chronology Books, Iowa.

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Creation in the News

Fast rock formation

IN the last issue, Paul Garner gave a report of an interesting discovery of the rapid formation of stone from mud. Though this surprised the conventional geological community, it was an interesting demonstration to creationists (particularly those sharing our young earth position) that the biblical account is testable—not in the laboratory alone but in observable natural systems.

Paul's response provoked considerable interest in Norfolk. Under the heading *'Creation theorists boosted by "fast fossil" find'*, the *Eastern Daily Press* commented on Paul's article. He is quoted, 'It adds to the accumulating evidence that sedimentary rock formation can take place much more rapidly than we thought.' Professor Kenneth Pye of Reading University does admit, 'It makes them [geologists] sit up and think.' Paul goes on to point out that rapid rock formation is not just an underlying requirement for young earth creationist belief, but is a necessary requirement for fossilization to have occurred.

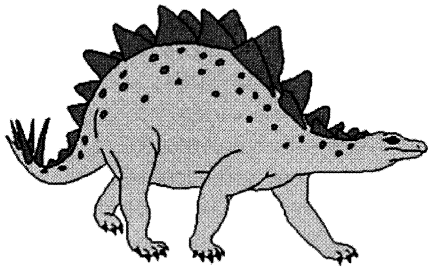
The discoverer of the find is content to see this as just another 'valuable discovery' which sits alongside all the other geological finds. Following the appearance of that article, Radio Norfolk rang us up and were pleased to give Paul a time slot on the next day, with essentially the same evidence being presented.

Dinosaur DNA

WE have reported previously on the discovery of DNA in supposedly ancient fossils. This does not make sense scientifically as we can demonstrate that DNA only has a lifetime of the order of ten thousand years. So, the fossils cannot be so old.

A recent report rubs salt into the wounds. Dinosaur bones have been excavated from a coal mine and studied by Scott Woodward of the Brigham Young University in Utah. They have extracted DNA from these bones. The fragment isolated contained 174 base pairs and the bones are supposed to be 80 million years old! The film *Jurassic Park* which was based on the recovery of dinosaur DNA from amber is clearly fiction, but one begins to wonder where the fiction ends when such contrary evidence is found.

These two pieces of evidence support our contention that the world is not so old as evolutionists would have us believe.



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FETTER, C. R. (1956), *A Critical Investigation of 'The Second Cainan' in Luke 3:16.* Unpublished. Grace Theological Seminary, Winona Lake, Indiana.

KITCHEN, K. A. and MITCHELL, T. C. (1980), *Illustrated Bible Dictionary.* IVP, Leicester. p.276.

MERRILL, E. H. (1981), *Fixed Dates in Patriarchal Chronology.* Bibliotheca Sacra, 137(547):241–251.

PEET, J. H. J. (1982–3), *The Chronology of the Judges.* Journal of Christian Reconstruction, 9(1–2):161–181.

PEET, J. H. J. (1985), *Bible Chronology.* Foundations, 14:19–29.

PEET, J. H. J. (1994), *The Bible and Chronology (1): The Historical Time Frame.* Origins, 7(18):10–12.

RENDSBURG, G. A. (1992), *The Date of the Exodus and Conquest/Settlement: The Case for the 1100s.* Vestus Testamentum, 42(4):510–527.

ROBINSON, S. J. (1995), *From the Flood to the Exodus: Egypt's Earliest Settlers.* Creation Ex Nihilo Technical Journal, 9(1):45–68.

SEWELL, C. (1995), *Biblical Chronologies Compared.* Bible and Spade, 8(1):20–31.

STIGERS, H. G. (1967), *The Interphased Chronology of Jotham, Ahaz, Hezekiah and Hoshea.* Bulletin of the Evangelical Theological Society, 10(2):81–90.

THIELE, E. R. (1977), *A Chronology of the Hebrew Kings.* Zondervan, Grand Rapids, Michigan.

THIELE, E. R. (1983), *The Mysterious Numbers of the Hebrew Kings (3rd edition).* Zondervan, Grand Rapids, Michigan.

THOMAS, D. W. (1958), *Documents from Old Testament Times.* Harper and Row, New York.

WILLIAMS, L. (1990), *The Mount Sinai Myth.* Wynwood Press, New York.

Chaos Theory: Uses and Abuses

Peter Senior

IT HAS always been the role of the scientific method to take observations that are perplexing in themselves and uncover the unifying and simplifying principles that underlie them. The study of Deterministic Chaos has arisen with the discoveries of families of patterns hidden beneath the surface of many phenomena which, until recently, seemed random in nature. The underlying forms have a complex texture in common with natural phenomena such as trees, clouds and coastlines, which are described by the new mathematics of Fractal Geometry.

It has also been recognised that many systems that have until now been taken for granted as extremely predictable, can also pass into and out of unstable behaviour of this type. Thus the realisation is dawning that some features of the universe, although they are governed by deterministic equations, are fundamentally unpredictable beyond limited horizons.

Overview

Newton's Laws of Motion and his theory of gravity are a handful of mental tools that have enabled everything moving around us from atoms up to galaxies to be analysed. They give rise to the reliable predictions that are the foundation of technology and engineering. Such calculations have always been accompanied by an analysis of the effect of measurement error or uncertainty upon the final answers. Studies of many natural phenomena have shown that, in trying to project today's measurements into the future, or trace them back into the past, the limits of uncertainty propagate away at an exponential rate that cannot be compensated for by bigger and faster computations.

Starting from today's measurements, a highly accurate prediction of the weather in seven days time is sometimes possible, but it would take ten days to run on the fastest computers in existence. Algorithmic Complexity Theory shows that, in some cases, it would take nine days to run on the fastest conceivable parallel computer, limited by factors such as the speed of light. On the other hand moderate reductions in the accuracy of the forecast rapidly reduce the computation time. This acceptance of unpredictability beyond limited horizons, as a fundamental feature of many aspects of the universe, is referred to as a 'paradigm shift', and usefully highlights the naïve excesses of uniformitarianism.

In the region between order and deterministic chaos, phenomena such as laser beams occur. These are referred to as 'complex systems displaying emergent behaviour' and are dealt with under the title of Complexity Theory or sometimes Anti-Chaos. This will be the subject of a subsequent paper. Chaos and Complexity Theory are branches of the relatively new discipline of Nonlinear Dynamics.

The complexity of natural shapes has been shown to be modelled by applying repetitive iteration or feedback to simple equations. This appeals to those trying to show that the complexities of life itself are mechanistically inevitable. As from other fields, such as Quantum Mechanics and Relativity, rigorous, refutable (testable) scientific concepts are being borrowed from Chaos Theory, by those attempting to find mechanisms that will support evolutionary philosophy. A wider circle of academics are finding Darwinism to be fundamentally inadequate, in the light of modern genetics, the lack of undisputed transitional forms in the fossil record and common sense. Somewhat surprisingly, common sense is a subject that the philosopher Professor David Stove (1994) appeals to. The following hints at the flavour of his paper:

> 'Most educated people nowadays, I believe, think of themselves as Darwinians. If they do, however, it can only be from ignorance: from not knowing enough about what Darwinism says. For Darwinism says many things, especially about our species, which are too obviously false to be believed by any educated person who retains any capacity at all for critical thought on the subject of Darwinism.'

There was a time when such a paper would not have been allowed in such a respected journal as *Philosophy*, but some feel that Darwin's contribution is not as essential as it used to be. The work below, and another paper to follow, should indicate how the arguments have moved on. The focus is upon the ultimate origins of the structure and information in living systems, and how it may multiply once they are operational.

Nonlinearity seems to offer the evolutionist a new hope to rise above the predictions of the old linear near-equilibrium thermodynamics. This is aided by the devaluation of the concept of information in the less than rigorous exploitation of Claude Shannon's Information

Stochastic equation: An equation that produces answers that are controlled by a probability distribution, or in the extreme, completely at random.

Deterministic equation: An equation modelling cause and effect. The same input variables always produce the same answers. In the case of Deterministic Chaos, the inputs must be identical to a very large number of decimal places.

Exponential Rate: A process following an exponential rate grows or shrinks very rapidly. The equation describing the phenomenon has time in the exponent of the number *e*, 2·71828..., which is the base of natural logarithms. That is to say that *e* is raised to the power of an expression including time.

Linearity: A linear process is purely the sum of its parts. Hence the linearity of a hi-fi system ensures that voice and instrumental sounds pass through without their tone being affected.

Nonlinearity: Wherever nonlinearity is encountered the elements of a system or process multiply together. In the case of acoustics, musical instruments are distinguishable from one another because of the different overtones or harmonics which each produces, even when sounding the same note on the scale. The overtones of even a single instrument will multiply together because of the nonlinearity of a low quality audio system, or a system of any quality that is driven toward its limits. Thus the new harmonics can give rise to further combinations *ad infinitum*, making the prediction of the final outcome extremely difficult if not impossible.

Topology: A mathematical study of the fundamental properties of objects that remain unchanged under the distortions they might undergo if made of extremely compliant rubber. In two dimensions shapes are characterised by the number of arcs (lines), nodes (points where arcs meet) and regions (areas enclosed by arcs). Two objects are topologically identical if one can be distorted to resemble the other without breaking arcs, or tearing regions (making new arcs). The familiar map of the London Underground is topologically equivalent to the geographical distribution of rail lines and stations, but gives no idea of distances.

Paradigm: A paradigm is a foundational, guiding principle. The Newtonian Paradigm made it seem reasonable that measurements of mass, length and time made in a vast number of natural and man-made systems, could be extrapolated over many orders of magnitude. The recognition of the prevalence of nonlinearity across the whole of nature and technology is referred to as the collapse of the Newtonian paradigm.

Theory. Shannon originally called his work Communications Theory, and it was implicit that there was ultimately a mind at either end of the communications channel. There is also a confusion between the information required to describe the configuration of a system, and the conceptual significance placed upon it by intelligent beings, according to a predetermined but arbitrary convention. The battle needs to be fought at the level of the presence of teleology in living systems. Teleology has subsystems developing independently that only have significance when acting in concert. Thus they are not optimised by local survival of the fittest, since in isolation the subsystems are not fit for anything. This will be developed in the paper on Complexity Theory.

It was argued in the past, by creationists such as Aw (1976), that near-equilibrium chemistry was not enough to create the life that is sustained by that chemistry. A new generation must study Nonlinear Dynamics and show its inadequacy also. But we must remember our paradigm, that salvation comes by faith and that not of ourselves (Ephesians 2:8). If Nonlinear Dynamics were not a reality, or had not been discovered, we would have found a Holy Grail in the old thermodynamic argument that could have forced a belief in a Creator by pure logic. The experience of creationists debating with the best of the opposition is that there is always an intellectual escape route in the most cogent arguments of Creation Science. Just as perpetual motion machines are ruled out by the 'Principle of the Conservation of Energy', so salvation through scientific argument *alone* is ruled out by a 'Principle of the Conservation of God-given Faith'.

However, this Creation Science must continue to be developed, to include Nonlinear Dynamics for instance, because it is a more accurate picture of the world and its history than the secular one. Wherever the Holy Spirit is working in the heart, the Biblical Catastrophist model will challenge an individual's faith in the mirage of a purely mechanistic explanation of ultimate origins. The very nature of nonlinear phenomena is such that final explanations always lie just over a horizon, or around a corner, and the evolutionist pursues these answers in faith, often with more faith than the mathematicians and physicists from whom he borrowed the ideas.

Dr. David Ruelle commented upon the exploitation of Chaos Theory in his book *Chance and Chaos* (1993, p.79). His credentials stem from his contribution to the analysis of the development of turbulence, the Ruelle Takens Theory. He makes the point that Chaos Theory can only be rigorously applied in those systems where there is a good knowledge of the basic equations controlling the dynamics, and which can be numerically integrated with precision on a computer. This is the situation in solar astronomy, the physics of fluids and even weather forecasting. In oscillating chemical reactions, the basic equations are not known, but long time series can be obtained with the required precision. The significance of this will be explained in the section on Strange Attractors.

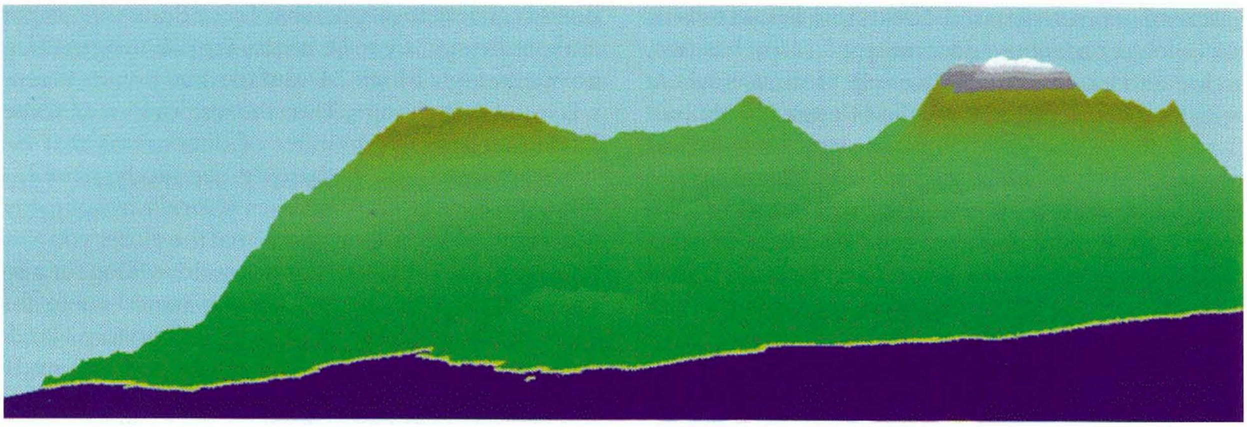


Figure 1: Fractal Scenery

He goes on to say that in the 'soft' sciences the equations are not known, and that models showing qualitative agreement are not enough. Precise, long time series are difficult to obtain. In many cases the basic equations slowly change with time, and the system is said to 'learn'. For such systems, the application of Chaos Theory must remain at the level of philosophy, rather than quantitative science. But as an evolutionist himself, Ruelle hopes that the situation will change, given that Henri Poincaré's thoughts on unpredictability in meteorology (see Chaos in High Places) were originally philosophy, but are now quantitative science.

Nonlinearity: The Whole is Greater Than the Sum of its Parts

It is easy to appreciate how a large number of things can interact in straightforward ways to produce chaotic, unpredictable behaviour. That is what shuffling a pack of cards is all about. In contrast, Chaos Theory (more properly Deterministic Chaos Theory) is about the revolutionary discoveries that have been made in studying systems that may consist of only a few items, but which affect each other in subtle ways. The technical name for this subtlety is 'Nonlinearity'. One may not have heard of the word, but one experiences its effects whenever one overloads a loudspeaker and an initially recognisable voice or musical instrument becomes distorted. The overtones which distinguish the sound of one instrument from another, multiply together. Thus one perceives the new frequencies as a change in the tonal quality of the existing instruments (possibly beyond recognition), rather than the appearance of extra new ones.

To analyse something is to break it down into more easily understood, 'bite sized pieces'. This can be done with a linear system because it really is just the sum of its parts. One of the essential features of a highly nonlinear system is that its behaviour is only evident when all its components multiply together, and it cannot be predicted by contemplating the parts separately. In the humanities such systems are said to require 'a holistic approach'. In mathematics it may only be possible to produce a simulation of a nonlinear system, and not an analytical solution. Running a simulation is often like playing a tape on a machine with no fast-forward button. One has to listen from the start, all the way through until the piece you want. Using an analytical solution is more like playing a record, or compact disc. One can immediately move to any point of interest in the programme.

Iteration: Amplifying Uncertainty

The position and speed of a clock's pendulum has been shown to follow a regular sine-wave pattern. When one is given the time for a single complete swing and its initial position, one makes a single calculation for its position for any given time in the future. This is the beauty of an analytical solution. In contrast when one is given all the necessary atmospheric measurements at a specific time, a very large, complex calculation may only move the weather prediction on by one hour. The simulation then takes these results as the input to the same calculation, for the next hour, and the weather forecast for tomorrow and the coming week is built up by repeating the process. In mathematics this is known as iteration, and engineers will recognise this as a form of feedback.

The limits of uncertainty present in the initial measurements fed into the equation, grow with each repetition, and rise in real time on an exponential curve. To balance this one can use shorter and shorter time steps for each iteration, but then the prediction grinds to a halt by a process of diminishing returns. The growth of uncertainty is dealt with below under 'Critical Sensitivity to Initial Conditions'.

Natural Shapes: Fractal Geometry

The way in which natural forms grow is interesting in itself, but the mathematics of natural patterns and textures are also found in the pictures that summarise the long term behaviour of deterministically chaotic systems. Some new ideas need to be introduced.

The school geometry passed down from Euclid tells us that a solid object has three dimensions, a plane has two, a line one and point zero. These are of course whole numbers, integers. A researcher called Benoit Mandelbrot (1982) working at the computer company IBM studied natural shapes such as coastlines, trees and lightning, and came up with a way of quantifying them based on two principles. Firstly natural shapes tend to have the same quality of roughness whether you look closely, or from a distance, and secondly they can be characterised by a non-integer number for the number of dimensions they occupy, as a measure of this roughness. He summed these points up in the following jargon. Natural objects are 'self-similar' with scaling, and are 'fractal', the latter being a word he adapted from the Latin *fractus* with the irregular and fragmented appearance of a broken stone in mind.

Self-Similarity

A mountain range has a similar angular appearance to the features on just one of its peaks, and even the individual rocks and crags, when one is close up. Examine the stem of a cauliflower. It has branches and sub branches such that the large white centre is made up of successively smaller florets that all resemble it. Sections of a piece of coastline have the same general mixed appearance of bays, inlets and peninsulas when zooming in, using maps of reducing scales. Thus an academic search began to classify natural forms (Sander, 1986; Stanley and Meakin, 1988; Schaefer, 1989).

Non-Integer Dimensions

A 'dust' of zero-dimensional points may begin to cover a two-dimensional plane, or appear like an unbroken line from a distance. A mathematician called Gioseppe Peano defined curves that could, in the extreme, snake around and visit every point on a plane. In the real world batteries and capacitors are more effective if their electrodes are microscopically pitted and rough, giving them an 'effective' area thousands of times greater than their 'planar' area. Chemical reactions on the surface of solid catalysts also benefit from microscopic 'roughness', and, as always, one needs a quantitative measure of such things, if comparisons and predictions are to be made. Try picturing in your mind an increasingly rough 2-D surface until it starts to resemble a layer of 3-D sponge. Thus the quirky idea of something having an effective number of dimensions that is not a whole number, can perhaps be seen to be useful.

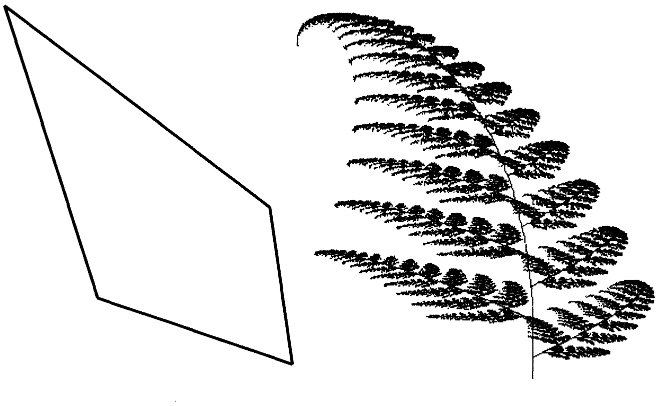


Figure 2: Fern generated by IFS

Mandelbrot (1982) discusses several ways of measuring the length of a coastline, given that the closer you look, the more detail you have to bend around, calling for a smaller and smaller ruler. At first sight it would seem that the measured length could go on rising indefinitely. Mandelbrot illustrated several ways of tackling the problem, and found a method put forward in 1919 by Hausdorff and finalised by Besicovitch. The Hausdorff Dimension D, more properly Hausdorff-Besicovitch, is now referred to as the Fractal Dimension. Basically the more the coast 'crinkles', and breaks up into offshore rocks and islands, the higher its fractal dimension D, rises above the Euclidian (or topological) value of 1, for a line. In chapter 28 he compares computer generated coastlines of known dimension with real ones. Simulations with $D=1{\cdot}3$ he found similar to Africa, South America and Greenland. As D rose towards 2 he was reminded of Finland.

The fern in Figure 2 was produced by a mathematical technique developed by Professor Michael F. Barnsley (1988) that he called iterated function systems or IFS. They are based on the idea of repeating the same routine over and over again on smaller and smaller scales. Thus the general form of the frond from a large fern is repeated, as it branches out to smaller copies of itself. Another technique called 'L-Systems' produces realistic-looking computer simulations of trees and flowering plants in three dimensions. Dr. Brian Goodwin (1990) summed up the new ideas such mathematics have prompted:

> 'A living organism doesn't have a shape like that of a circle, that is just static and sits there. Living organisms are dynamic forms ... The importance of fractals in understanding how complex shapes are formed in organisms, is that they allow us to see how really quite simple rules, iterated over and over again, can generate complex form ... If we believe that plants grow according to rules of the type we see in Fractal Geometry, then in fact we can begin to explore these rules and find out which ones can operate and which can't. Then we can take the next step, which is to say that evolution is an equivalent exploration of rules of this kind, and then we can understand which forms are possible, and which forms are impossible, that could not be generated by biological systems.'

He also had some unconventional ideas as to where these rules were to be found:

> 'A lot of people, I would say the majority of biologists, believe that they are encoded in some form in the DNA; that you have a genetic program that actually instructs the plant, the growing plant, what to do and how to generate these forms. My colleagues and I have a much more radical proposal to make, which is that the rules

are actually embodied in the basic physical and chemical organisation of the generator: the tip of the plant or the 'maristem', and that is where all the complexity is generated by means of very simple rules.'

Strange Attractors: The Patterns Behind the Chaos

Perhaps the most familiar examples of Chaos Theory come from the weather. Indeed it was the meteorologist Edward Lorenz (1963) who published a paper that added to the realisation amongst scientists that a variety of obscure research in the previous hundred years illustrated a common underlying, unifying principle or 'paradigm'. Unfortunately the journal was not widely read and his contribution was not appreciated for many years.

Lorenz had set up a sizeable array of differential equations, to see if he could capture some of the general behaviour of weather systems. He was integrating them numerically on a digital computer. The results were calculated to six decimal places, but only displayed as three. When he typed in the results from half way through a simulation, as the starting point of a new run, he observed something curious. The new results gradually moved away from the old ones, rather than matching until they ran beyond them. In those days it was likely that some electronic valve had failed in the computer, but all such sources of error were eventually eliminated.

He finally realised that his calculations were sensitive to the fourth place of decimals and beyond, that he had initially neglected. He went on to find that dissipation in his system meant that the long term behaviour was dominated by only three equations. He found that he could represent their general behaviour in a single picture.

Let us first consider a simple example, and then apply the lessons to Lorenz's equations. All that is needed to predict the behaviour of a simple undamped pendulum can be summed up on a graph of its position against its momentum. Since its mass is constant, the momentum axis can be simplified to be its speed. In general the graph is an ellipse, but fiddling with scales on axes produces a circle for convenience. This is known as the 'phase diagram' for the undamped pendulum. When the pendulum swings out to maximum displacement, its velocity is momentarily zero, and climbs back to a maximum as it swings through the midpoint of zero displacement. The time history of the pendulum is a point endlessly moving around the circle 'in phase space'.

If frictional losses are added, the circle is broken, and the point in phase space spirals inwards to the point 0,0. To counter this we can provide some periodic driving force that exactly balances friction, as in a grandfather clock, and the phase portrait becomes circular again. The final lesson from the phase diagram of a driven damped pendulum, is that if our clock is bumped, the circle in phase space is temporarily distorted, but friction removes the wobble, and the original shape returns. The circle is said to be the 'attractor' for the driven dissipative system. Without any driving force the system had a 'point-attractor' at (0,0). Without dissipation, any transient disturbance to the system would be 'remembered' as a permanent distortion of the motion.

So it was that Lorenz plotted the results of the numerical integration of his three differential equations as points in a perspective drawing, in their own three-dimensional phase space. The picture is the deceptively simple one shown in Figure 3, known as the Lorenz Attractor. If it can be perceived in three dimensions, it is basically two discs at an angle, rather than the circle traced by the pendulum described above. Again, the effect of an imaginary, temporary, vast forest fire for example, might perturb his weather system, but the roving point will eventually settle back onto the attractor, courtesy of frictional losses. Significantly though, it will not return to the line it left.

The attractor has been plotted out with a change in colour in Figure 3 to help to show how often the line moves from one disc to the other. The simulation was stopped early, in order to prevent the essential details being lost in a mass of later lines. This particular snapshot captures two of the most important features of the attractor. Firstly, it is not possible to tell when the point will migrate from one disc to the other. Secondly, when it returns to the original disc, it may either resume similar behaviour, spiralling into the centre for instance, or it may interleave with a track it made much earlier.

If the simulation had continued, the interleaving would have become impossibly dense. Only by zooming in would we have been able to make out any detail, given that our real line has to have a finite thickness. The mathematics predicts that the lines never cross, and this implies something that is not immediately obvious. Every time the line crosses to the other disc it does so to a slightly different level. That is, the discs are not flat; they are made up of an infinite number of finely separated layers. The attractor thus has a larger fractal dimension than casual inspection would suggest. Jumping ahead somewhat, it is now known that if any nonlinear dynamic system displays deterministic chaotic behaviour, rather than being truly random or 'stochastic', it will be found to have a fractal or 'strange' attractor. This seems to be 'Catch-22'. If we had the equations to integrate to obtain the attractor, we would know it was deterministic. Without the equations, how do we plot the attractor? We do not know how many different variables we must measure simultaneously to get a point on it, *i.e.* how many topological dimensions it has, and we are not limited to only three. Fortunately it has been found possible to develop the attractor from an extremely long series of accurate measurements of less than the optimum number of variables. Hence the reference to oscillating chemical reactions paraphrased from Ruelle in the introduction.

The final point about the Lorenz Attractor sums up his problems with starting with data to three instead of six decimal places. The two sets of data lay on two lines in the

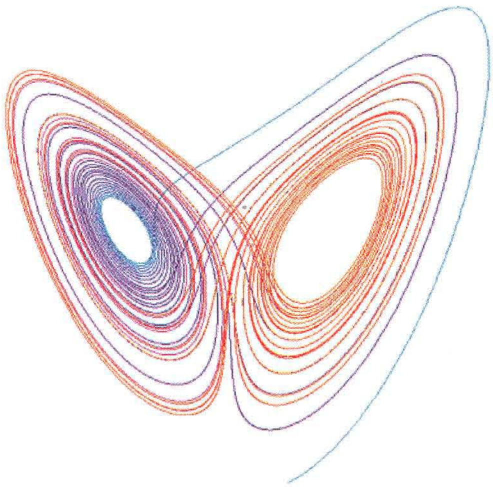


Figure 3: Lorenz Attractor

attractor initially running parallel, but one of them flipped to the other disc, changing the weather completely after a short time. Two points side by side on the attractor, and arbitrarily close together, will always separate at some time in the future. Sometimes sooner, sometimes later. It is thus said that Chaotic systems display a *critical sensitivity to initial conditions.*

There is a further quality that makes an attractor in phase space 'strange', so here is a summary of the three necessary conditions.

The pattern in phase space must:

1. Be a Fractal, having non-integer dimension and showing self-similarity when zooming in.
2. Display sensitive dependence upon initial conditions. No matter how close two lines are to each other, they will ultimately separate widely.
3. Have a continuous frequency spectrum, despite having a finite (but not integer) number of dimensions.

The significance of the last condition would take too long to explain, but was needed for completeness.

The Butterfly Effect

Condition 2 above led to Edward Lorenz making a comment about the beat of a butterfly's wing in South America ultimately diverting the course of a hurricane across Florida, and the term 'Butterfly Effect' was born. In predicting the weather, our calculations were shown above to be sensitive to the accuracy of their input data. But once we have measured everything we need, with incredible accuracy, the atmosphere itself is subject to disturbance. Let us consider an extreme example given by Ruelle (1993, p.75). He gives references to where the original calculations were made, but these are omitted for brevity.

1. Let the Earth experience a change as small as momentarily removing the gravitational effect of a single electron at the furthest extent of the observable universe.
2. After as little as 50 collisions each, over a tiny fraction of a second, air molecules are bumping into different neighbours, than they would have done without the disturbance.
3. Wherever there is turbulence, differences are multiplied rather than damped out, and after one minute the changes have reached a millimetre scale.
4. Kolmogorov turbulence equations (not perfect, but useful) predict that wherever there is a storm, the local effects are magnified to a scale of kilometres in a matter of hours. The clouds now have a different shape, and the wind is gusting differently.
5. After two weeks the pattern of the global weather system is noticeably different.

Chaos in High Places

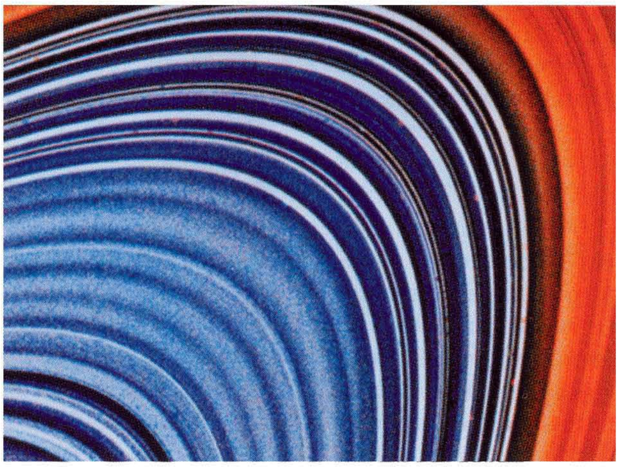
We have the science and technology of today because systems like the weather seem exceptional, across the scales of space and time that we can experience directly. Isaac Newton gave the world a set of laws governing mechanical systems in motion, and a mathematical tool called fluctions (later superseded by differential and integral calculus) with which to apply them. The principles embodied in his Laws of Motion were effective across the widest possible spectrum from the smallest to the largest objects that mankind could discover. Only at the beginning of this century did the sub-atomic realm, and objects approaching the speed of light call for new thinking. The apparent universal relevance of Newton's equations of motion led to a fundamental philosophical assumption or paradigm, which was put into words by the mathematician Pierre Simon de Laplace (1749–1827):

> 'Given for one instant an intelligence which could comprehend all the forces by which nature is animated and the respective positions of the beings which compose it, if moreover, this intelligence were vast enough to submit these data to analysis, it would embrace in the same formula both the movements of the largest bodies in the universe and those of the lightest atom; to it nothing would be uncertain, and the future as the past would be present to its eyes.'

Do not however mistake Laplace's supreme cosmologist for God. Being outside of time, God does not have to calculate backwards or forwards from any particular point. Every instant of Creation is equally accessible to his direct participation.

The paradigm, of course, is explicitly expressed in Uniformitarianism, 'the present is the key to the past'. This is used to justify the practice of extrapolating back over vast geological ages the interpreted results of selective observations made over a few lifetimes. Even before Galileo gave us the telescope, astronomical predictions of eclipses and the like had assured us that the present is the key to the future. The existence of Neptune was predicted from the disturbance it caused to the orbit of Uranus, and in its turn Pluto was searched out because of the perturbations it caused. The calculations even told one approximately where and when to look. It was Henri Poincaré's investigations into just how 'approximately' that made major contributions to Chaos Theory, although they would not be recognised as such for many years.

By observation, Johannes Kepler gave us his laws of elliptical planetary motion. Newton's equations confirmed these empirical relationships as being the consequences of an inverse square law of gravitation. But Newton's differential equations were found to have obvious analytical or 'closed' solutions for only two bodies attracted by gravity. While some searched for exact solutions for more objects, others developed approximate methods based on calculating a perfect two body solution, and then distorting, or perturbing it with the effect of a third. These are known as 'perturbation methods' for the solution of 'Newton's three body problem'.



Saturn's C-Rings

The word approximate should not be despised. When properly developed, such mathematical routines merely have to be repeated over and over again, effectively filing and polishing the result until it is as accurate as one could desire, if not looking too far into the future or the past. However, if anyone ever thought that one day such a rigmarole would cease to be necessary for the three body problem, Poincaré shattered their dream at the end of the last century. He developed qualitative methods to analyse systems of differential equations involving topology, to predict in general what was or was not possible, without calculating a lot of specific cases.

A Poincaré section is effectively a huge piece of paper, hanging in space at right angles to the Earth's orbit. If there was only the Sun keeping the orbit elliptical, it would only punch one hole in the sheet, and pass through it once a year. But the gravitational effect of the other planets, and especially massive Jupiter, distort the simple orbit. Poincaré studied what happened to orbits that were slightly perturbed. He found some that would make several holes before repeating themselves, and others that made a pattern in the paper, without ever exactly passing through the same hole again. He also found that the patterns repeated endlessly as he zoomed in. We now describe them as being Fractals. In fact Poincaré sections possess the three properties of a strange attractor given above.

He discovered that periodic orbits are the exception rather than the rule, under Newton's deterministic equations, and that there is no theoretical justification for assuming that the behaviour of the solar system will be endlessly stable. Without a God who makes promises about the future, the universe has always been a frightening, uncertain place. Simulations have shown the planets to be safely stable, but one should look at the surface of the moon, and consider that it was not pock marked when Adam first looked at it. It has only taken thousands of years to get to its present condition. However the asteroid belt was formed, and it has the ragged appearance of a post-Fall phenomenon, there would have been a considerable settling period where a lot of random material would have been vandalising the inner solar system.

It is evident therefore that there have been times in mankind's past when fire fell from heaven far more often than it does now. Some believe that the Lord used an asteroid or cometary glancing blow to precipitate the Genesis Flood. Such an event would certainly break up the fountains of the great deep. It would also explain why the civilisations we know about after Babel obsessively watched the sky with more fervour than is really needed to predict the seasons. Would the great mountain in the heavens come back? If the sky was busy with signs and wonders, perhaps it explains why the tower of Babel itself was considered worth building. In our day, the thought of a shower of nuclear missiles greatly increases the fear of man in the world. Perhaps great showers of flaming meteors will again put the fear of God back into the world.

Chaos in Small Places

Mention of uncertainty usually calls to mind the subatomic world of Quantum Mechanics. There are some situations that can be analysed by using both Newton's equations and Shrödinger's. In these cases, to add to the paradox, it has been found that the former are more chaotic than the latter (Pool, 1989a; Berry, 1991).

Until one discovers that electrons orbiting a nucleus like classical planets should radiate their energy as electromagnetic waves, and crash into it, one is tempted to think of tiny solar systems. Quantum Theory was developed to predict allowed orbits in which this will not occur and the disallowed bands in which no electron can remain. However, perhaps astronomy still holds some lessons. The American Daniel Kirkwood discovered in 1867 that the asteroid belt contained clear orbits with nothing in them. He correctly associated these with orbital periods resonant with those of Jupiter, which tends to perturb most things in the Solar System, because of its great gravitational mass. The forbidden orbits are known as Kirkwood Gaps. An asteroid is due to leave the edge of such a gap and pass close by the Earth in 2004.

Moving down by an order of magnitude, to the rings of rocks and particles orbiting Saturn, close-up photography by Voyager probes has revealed that they have a self-similar fractal structure of gaps. In this case it is proposed that the resonant interaction between the rings and Saturn's moons defines orbits from which objects are ejected. However, the author is unaware at present of any numerical model which has been able to demonstrate this. Simulations of millions of years have been run, without success, and these timescales are way beyond what Scripture would allow. This is unfortunate, as those who believe that the quantised electron energy levels of the atom are due to 'hidden variables', might have had an inverse analogy to exploit.

The Logistic Equation

A Poincaré section intercepts a planetary orbit at just one position, and gives a 'map' of the behaviour of neighbouring perturbations. This is an example of a general technique in nonlinear dynamics, where a smoothly changing variable is only sampled at discrete points. Let us consider a population of animals for instance. It moves up in the breeding season, and generally down, when conditions are hard—in winter for instance. The logistic equation was developed to examine the variation in population year by year, and so it uses a single value of population, recorded at the same 'date' each year. The variable is thus called 'discrete' as opposed to 'continuous'.

It is known that a habitat can only support a certain maximum population, and so the situation is generalised by making the population x, a fraction of this value in any year,

i.e. x varies between 0 and 1.

x_t is this year's population, x_{t+1} is next year's.

R is a parameter that represents the overall effect of birth rate against death rate.

$(1-x_t)$ is a figure that is used to show the effect of overcrowding, leading to food shortages and the like.

$$x_{t+1}=Rx_t(1-x_t)$$

If R is less than one, the population declines. Between 1 and 3 the population may dither about for a few years, depending on the value it starts from, but it tends towards a stable value. From 3·0000 to 3·4495, after a dithery start it alternates between two values, between 3·4495 and 3·5441 it cycles around 4 values, beyond 3·56441 there are 8, and soon chaos reigns.

Figure 4 shows how the number of possible population values keeps on doubling as R increases, it is known as a pitchfork bifurcation diagram, and illustrates 'period doubling'. The period of any function is the time it takes before it repeats itself. For R just greater than 3·5441, it is eight years before a population value repeats itself. For this value of the parameter the logistic equation is therefore said to have period eight.

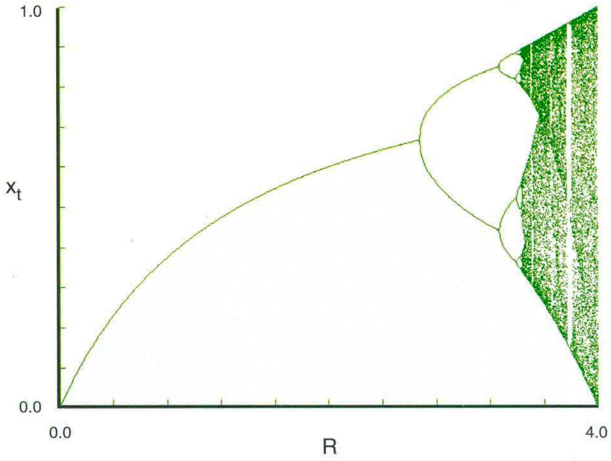


Figure 4: Bifurcation diagram

If you open a tap slightly, water begins to leak in single droplets, drip, pause, drip, pause, drip. If the tap is opened a little further, the flow develops period two, drip drip, pause, drip drip, pause, drip drip. A well made tap, carefully opened, will exhibit period doubling all the way up to a chaotic cascade. The dynamic pattern is often encountered in convection studies, but is only one of several routes to chaos (Eckmann, 1981). A famous study was published by Feigenbaum (1978) who used the term 'Universality' in his title. This referred to a particular technical feature of the 'Renormalisation Group' approach, and has led to a general impression that period doubling is more dominant than it actually is. Besides the pitchfork there are also Hopf bifurcations for example (Eckmann, 1981). All this enthusiasm has had to be balanced by a reminder that biological systems rarely produce totally pure, unalloyed phenomena. Ruelle's caution is well founded, and cases of misunderstanding are documented (Pool, 1989b; Ruelle, 1990).

The bifurcation diagram is repeated in Figure 5 for a narrower range of R. Note the regions where the vast numbers of different possible populations reduce to as few as three. In more general, large systems, over historical

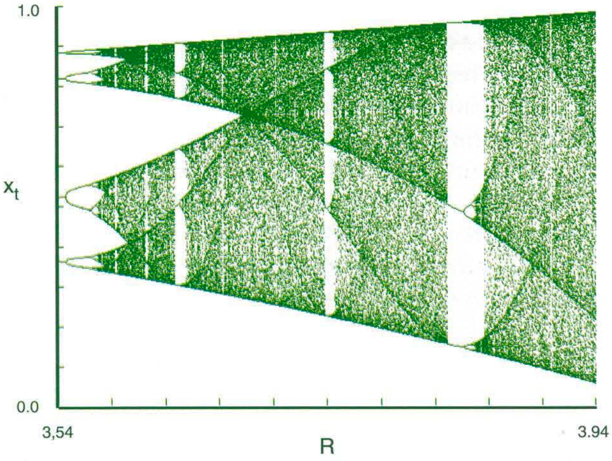
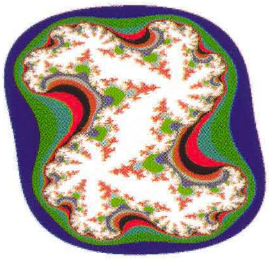


Figure 5: Bifurcation diagram

time periods, who is to say that the order that we have been accustomed to is not sensitively dependant on some ecological R which may change. This is the reason for the need for the reduction of man-made global warming. We cannot say what new patterns of weather may suddenly appear when the atmosphere's mean temperature passes some unpredictable threshold.

Julia Sets



With iteration, or feedback, even the simplest nonlinear equations can give rise to highly complex behaviour. Gaston Julia (1893–1978) made predictions about such situations around 1918, but lacked the computing power to fully investigate them. The equation of interest is

$$z_{i+1}=z_i^2+C,$$

where z and C are complex numbers (see Appendix). Thus each z can be drawn as a point on an x,y graph. This is known as the complex plane, and the two axes are known as real and imaginary rather than x and y. As in the case of the logistic equation we are calculating the next answer based on the previous one. Some points go to infinity, sooner or later; some points never do. The boundary between the region of points that zoom off, and those that do not is called the Julia Set. Each C has a different Julia Set, and the mixing of the real and imaginary parts of complex numbers under multiplication (see Appendix) makes the shape of the set unpredictable in the region around the origin.

Some Julia Sets have continuous boundaries, making it easy to say what is inside, and what is outside. Some sets are made up of discontinuous points, and are known as a 'dust'. A dust point is a value of z that does not zoom off, but it is surrounded by points that do. If the number of iterations before z gets out of a circle, centred on the origin, radius 2, is recorded, one gets a feeling of how fast the numbers grow as you approach a Julia point or boundary. If z gets outside this circle it will definitely grow indefinitely and so it is safe to stop iterating.

If you also decide that if the number has not escaped after 256 iterations, it never will, one has a number associated with each point that could be associated with one of 256 colours, commonly available on modern home computers. Next, one has to decide how small a range of C one is going to distribute across a screen of 1024x768 pixels for instance. Thus one produces a coloured contour map. Blocks of the same colour are all points that escaped after the same number of iterations. One can change the shape of boundaries near the Julia Set by associating colours with a wider range of iterations. There is no guarantee that some values of z do not leave after 1,000 iterations.

Cover Picture: The Mandelbrot Set

Benoit Mandelbrot studied under Gaston Julia and much later when working for IBM fully exploited the computing power available to him. In examining the equation that produced the great variety of Julia Sets, he discovered a recurring shape that bears his name. He discovered it when investigating a whole range of values of C. A point on the screen is a value of C, and the iterations always begin with z=0. The colour of the point again indicates how many iterations it took before the answer got outside the circle of radius 2. The Mandelbrot Set is the region of values of C that never escape. Sometimes the iterations are attracted to a single point. Others orbit a point, some smoothly, others chaotically, but they never leave the circle.

A point inside the Mandelbrot Set is a value of C that has a Julia Set with a continuous unbroken boundary. Outside the Mandelbrot Set any value of C produces a Julia Set that is broken up into separate fractal regions that can be as fine a dust.

Top left in the cover picture, is the circle of radius 2 in green. The outer blue stretches to infinity, the inner blue is the Mandelbrot Set, an infinitely convoluted numerical black hole from which nothing escapes. It has a fractal boundary that is infinitely detailed, no matter how much one zooms in.

There is a small rectangle drawn in the smallest frame, left of centre. The picture to the right is the region of the rectangle blown up to occupy the whole computer screen. It too has a small rectangle, below centre. This was enlarged to occupy the whole screen and the whole cover picture, but it is now partly obscured by the smaller frames.

In the bottom half of the cover picture, there are visible at least four copies of the Mandelbrot Set of different sizes. One can zoom into their boundaries indefinitely finding still smaller copies. Theory has shown that all the infinite number of Mandelbrot Sets of vanishing size, are linked by an infinitesimal filament. The filament will of course remain below visibility at any resolution, except to reveal more Mandelbrot Sets along its length.

Thus the simple iteration of an elementary equation, elegantly gives a glimpse of a small corner of the new universe of nonlinear dynamics.

Chaos and Catastrophes

The French mathematician Renée Thom caused a stir in the 1970's with his Catastrophe Theory. It was taken up and applied vigorously by Christopher Zeeman of Warwick University, who cited many situations that could be explained by it. The theory pertains to dissipative dynamic systems, as does Chaos. Practical examples are considered by McCrobie and Thomson (Berry, 1991, chapter 12), with the parallel phenomena of 'homoclinic tangles' in strange attractors. These were discovered by Poincaré.

An excellent short overview of the relevant work of both Thom and Poincaré has been written by Ivar Ekeland (1988). In the case of Catastrophe Theory though he found it to have been forced into inappropriate situations, as undoubtedly has and will be done with Chaos Theory. On page 102 he goes further though and offers the opinion that,

> 'In the twenty years of its existence, there has not been a single undisputed success of Catastrophe Theory in the field of experimental science, that is, an undisputed fact that could be explained more adequately by Catastrophe Theory than by other means.'

The Uses of Chaos Theory

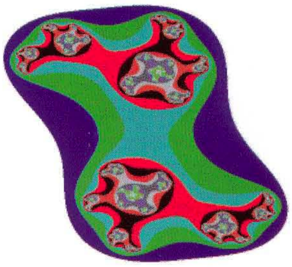
The following are but a few examples of the exploitation of the new ideas. It is the author's firm conviction that Creationists must keep up with the underlying principles as the battle lines move on.

Metaphysical

The principles of Chaos Theory illustrate that:

1 Creation is infinitely detailed and intricate, putting the most extreme claims as to the omnipotence of Scientism in perspective.

2 The Sterile Geometry of Euclid, stands against the Fractal Geometry of Creation, somewhat as the creativity of man stands against that of his Creator. In Creation no matter how close you look, there is always more to see.



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Diagnostic

Chaos may provide a healthy flexibility to the heart, brain, and other parts of the body. Conversely, many ailments may be associated with a loss of this chaotic flexibility. Chaos in bodily functions signals health. Periodic behaviour can foreshadow disease (Pool, 1989c; Goldberger *et al.*, 1990).

Technological

The extreme sensitivity to initial conditions that chaotic systems display makes them unstable and unpredictable. Yet that same sensitivity also makes them highly susceptible to control, provided that the developing chaos can be realised in real time and that analysis is then used to make small control interventions. This strategy has been used here to stabilize cardiac arrhythmias induced by the drug ouabain in rabbit ventricle. By administering electrical stimuli to the heart at irregular times determined by Chaos Theory, the arrhythmia was converted to periodic beating (Garfinkel *et al.*, 1992).

An analogue circuit implementation of the Chaotic Lorenz system is described and used to demonstrate two possible approaches to private communications based on synchronised chaotic systems (Cuomo and Oppenheim, 1993).

The Abuses of Chaos Theory

Metaphysical

1 Beginning with the assumption that rule-based systems do not need a mind to conceive them, and then other minds to perceive them, the richness of Fractal Geometry is used to put forward the possibility of natural creativity without consciousness, leading from molecules to man. This will be further explored by the author in *Complexity Theory: Uses and Abuses.*

2 Theories as to highly nonlinear catastrophic processes in geology were embraced by Marxist academics as exemplifying a natural principle that made universal political revolution inevitable. Conversely, contemplating uniformitarianism helped western conservative intellectuals sleep soundly in their beds. One's philosophy determines which scientific models one borrows.

Conclusions

Newton said that he felt his discoveries were but a few pretty pebbles on the beach of a huge ocean of the unknown. The progress made by science over the years based upon his discoveries made the comment seem somewhat over-modest. But now with nonlinear dynamics before us, his comment has an air of prophecy about it.

Evolutionists are now trying to convince each other that somewhere out there, in cosmic phase space, was a teleological fractal dust, that a metaphysical maelstrom mixed together to form a code, which ecological turbulence amplified into the biosphere we have today. If the author did not have the Manufacturer's Handbook for this universe, and regard the Creator's Revelation as having ultimate authority over His creatures' research, he would also be spellbound by this vision. But since he does have the Bible, the author suggests that this New Evolution is the most enchanting science fiction, which has the most devastating eternal consequences for those who hold it to be history.

APPENDIX: COMPLEX NUMBERS

A complex number z, consists of two parts, x and y which are often written as

$$z = x + iy \text{ or } x + jy$$

Engineers, scientists and mathematicians use i or j interchangeably, but always understand that in context it stands for the same thing. x is called the 'real part of the complex number', and jy (or iy) is known as the 'imaginary part'. The latter terminology is unfortunate as both parts are equally useful.

$$i = j = \sqrt{-1}, \text{ so, therefore, } i^2 = j^2 = -1$$

When one adds complex numbers together, real is real and imaginary is imaginary, and never the twain shall meet.

$$z_1 = x_1+jy_1;\ z_2 = x_2+jy_2;\ z_3 = z_1+z_2 = (x_1+x_2)+j(y_1+y_2)$$

When one multiplies them together though, the real and imaginary parts mix together.

$$z_1z_2 = (x_1x_2 - y_1y_2) + j(x_1y_2 + y_1x_2)$$

The second term is jy_1jy_2, which is $j^2y_1y_2$, since $j^2 = -1$ the term becomes $-y_1y_2$.

References

Readers with limited time are directed to work by Berry (1991), which gathered together articles that appeared in issues of *New Scientist.*

Aw, S. E. (1976), *Chemical Evolution.* Singapore University Education Press. Also (1982), Master Books, California.

Barnsley, M. F. (1988), *Fractals Everywhere.* Academic Press, New York.

Berry, M. (1991), *Quantum Physics on the Edge of Chaos.* The New Scientist Guide to Chaos, Hall, N., Editor, Chapter 15, pp.184–195.

Cuomo, K. M and Oppenheim, A. V. (1993), *Circuit Implementation of Synchronised Chaos with Applications to Communications.* Physics Review Letters. 71:65.

Eckmann, J.-P. (1981), *Roads to Turbulence in Dissipative Dynamic Systems.* Reviews in Modern Physics, 53:643–654.

Ekeland, I. (1988), *Mathematics and the Unexpected.* University of Chicago Press.

Feigenbaum, M. J. (1978), *Quantitative Universality for a Class of Nonlinear Transformations.* Journal of Statistical Physics, 19(1):25–52.

Garfinkel, A., Spano, M. L., Ditto, W. L. and Weiss, J. N. (1992), *Controlling Cardiac Chaos.* Science 257:1230.

Goldberger, A. L., Rigney, D. R. and West, B. J. (1990), *Chaos and Fractals in Human Physiology.* Scientific American, (February):34–41.

Goodwin, B. (1990), *Antenna.* (December);BBC 2.

Lorenz, E. (1963), *Deterministic Nonperiodic Flow.* Journal of the Atmospheric Sciences, 20:130–141.

Mandelbrot, B. B. (1982), *The Fractal Geometry of Nature.* W. H. Freeman and Co., New York.

Ott, E., Sauer, T., Yorke, J. A., Editors (1994), *Coping With Chaos.* John Wiley & Sons Inc.

Pool, R. (1989a), *Quantum Chaos: Enigma Wrapped in a Mystery.* Science, 243:893–895.

Pool, R. (1989b), *Ecologists Flirt With Chaos.* Science, 243:310–313.

Pool, R. (1989c), *Is It Healthy to Be Chaotic?* Science, 243:604–607.

Ruelle, D. (1990), *Deterministic Chaos: The Science and the Fiction.* Proceedings of the Royal Society of London, 427A:241–248.

Ruelle, D. (1993), *Chance and Chaos.* Penguin, London.

Sander, L. M. (1986), *Fractal Growth Processes.* Nature, 322:789–793.

Schaefer, D. W. (1989), *Polymers, Fractals, and Ceramic Materials.* Science, 243:1023–1027.

Stanley, H. E. and Meakin, P. (1988), *Multifractal Phenomena in Physics and Chemistry.* Nature, 335:405–469.

Stove, D. (1994), *So You Think You Are a Darwinian?* Philosophy 69:267–277.

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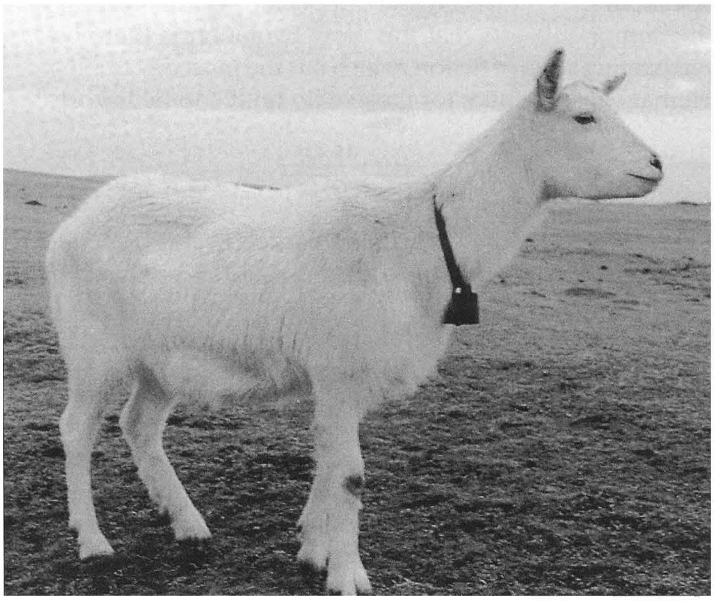
Jacob's Experiments in Goat Genetics

An example of special revelation

Ewan More

I HAVE heard Jacob described as the first geneticist but have not found an explanation or defence of that designation. The reason I would want an explanation is that the account of Genesis 30 seems to have little to do with genetics; indeed, at first glance it seems to have a lot more to do with superstition!



Since preparing for a Bible study on Genesis, I have continued to gather facts on goats and their genetics. (I am not overlooking the possibility that the whole event was overseen by God who controlled the outcome. However, in this paper we will see that the results are consistent with the normal laws of genetics).

Goats played a very important role in the Old Testament. The nanny-goat was an excellent source of milk and would yield 3·5 litres (6 pints) a day (Thompson, 1992). The goat was a very useful animal, providing milk, meat and skins. In biblical times the size of a flock was the visible sign of a man's wealth and large flocks were not unusual; Nabal had 1000 goats. When kept with sheep, goats tended to be the dominant animals in the group (Thompson, 1992).

It seems that I am not the only one to be confused by the biblical account. In a letter to *Nature* it was suggested that Lamarkian inheritance was practised by the patriarch Jacob as recorded in Genesis 30:27–43. The correspondent then went on to suggest renaming 'Lamarkian genetics' as 'Jacobian genetics' (Lindahl, 1981).

To understand what was being suggested, we need to know what Lamarkism is. It can best be explained using the example of the blacksmith or the giraffe. The blacksmith, by continued exercise, developes a good physique, working in the equivalent of an exercise gym. Lamarkism would suggest that his sons would inherit a similar physique, by virtue of their father's lifestyle. The story of giraffes is similar. Giraffes with short necks would supposedly stretch them by reaching for tree foliage. Their offspring would then have longer necks and they, in turn, would stretch them further. With each succeeding generation, the neck of the giraffe would progressively lengthen until we have the present day long neck.

Lamarkism has, of course, been disproved. The most famous experiment involved mice. When mice had their tails amputated at birth, their offspring were still born with tails. This was continued over many generations but all mice were born with tails, even if their father, grandfather, great grandfather, great great grandfather all had their tails removed (Jones, 1993). A modern example might be pedigree cocker spaniels, for which the breed standard required the tails to be docked. Despite generations of spaniels with their tails docked, each spaniel puppy is still born with a tail.

The Biblical record of Genesis 30 seems to be explicable as an example of the belief in prenatal conditioning (Guthrie, 1992). This theory proposes that, for example, the experience of a woman during pregnancy would influence the development of the baby. According to the theory of prenatal conditioning, an expectant mother visiting a zoo, being frightened by an elephant might then give birth to a child with elephant-like big ears! Of course, this is nonsense and is contrary to the known laws of genetics.

Jacob was obedient to God, however limited his understanding.

If we read on (always a good idea with Scripture) to Genesis 31:12, we find that Jacob was actually practising artificial selection as revealed to him by God in a dream.

GLOSSARY

Allele: Genes are the sections of DNA on a chromosome that contain the information for a particular characteristic. For example, in vestigial wing fruit flies, there is a gene controlling wing shape on chromosome 2. There are two forms of the gene, normal and vestigial and these different forms are called alleles.

Homozygous: Most living organisms have two copies of each chromosome, one coming from the father and one from the mother. These can be either the same or different. When they are the same, they are said to be homozygous. When different copies of the same gene are inherited, they are said to be *heterozygous.*

Dominant: When an allele produces the same character, whether it is present twice (homozygous) or as a single copy, it is said to be dominant. The word *recessive* is used to describe an allele which can be masked or hidden by a dominant allele. A recessive allele will only become visible when it is present twice (homozygous).

Phenotype: This describes the outward appearance of the organism.

Genotype: This is the genetic make-up.

In this revelation, he was directed to breed Laban's nanny-goats with his own spotted billy-goats. This is the first example we have of the practice, if not an understanding, of goat genetics. (The fact that Jacob continued to use his poplar, almond and plane rods, as well as selective breeding, is sufficient reason to doubt his understanding of goat genetics. Jacob was obedient to God, however limited his understanding.)

Jacob deliberately used spotted billy-goats to breed with the nanny-goats in Laban's flock. By overseeing the mating, he was able to control the outward appearance of the kids. We can discover how successful he was by examining the genes which control coat colour in goats. There are a total of six genes currently documented, these contribute to coat colour and its distribution in goats. For those not familiar with the genetics of coat colour, it is important to realise that some genes contribute to coat colour while others control the distribution of that colour. For example, the colour of a Dalmatian dog may be brown or black and is controlled by the two alleles of the gene for coat colour: B = black, b = chocolate brown. A second gene then controls the distribution of that colour. The extreme spotting found in the Dalmatian is caused by a recessive allele (Anon, 1982) and, as the breed standard is for spotting, all Dalmatians must be homozygous for this recessive allele.

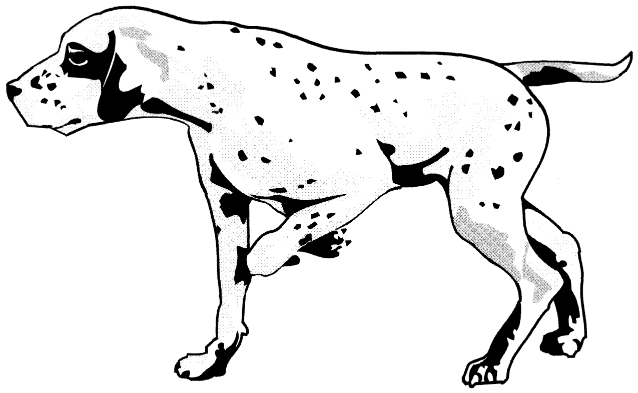


Figure: Allele effect in Dalmatian

In goats, the allele for 'spotted' is dominant to non-spotted (Lauvergne, 1982). The presence of the spotted allele, would thus cause the spotting of the coat whatever colour that happened to be. This means it is possible to look at the spotting gene in isolation, ignoring the other five genes (one of which has eight alleles!)

Laban's Flock

In the crosses practised by Jacob, a male billy goat phenotypically spotted (sometimes called piebald) would be crossed with a female nanny goat, phenotypically non-spotted. There are two possibilities for the billy goat. He

Possibility 1

Phenotype	Spotted Billy Goat x Non-spotted Nanny Goat
Genotype	Ss ss

Offspring

	s	s
S	Spotted Ss	Spotted Ss
s	Non-spotted ss	Non-spotted ss

Possibility 2

Phenotype	Spotted Billy Goat x Non-spotted Nanny Goat
Genotype	SS ss

Offspring

	s	s
S	Spotted Ss	Spotted Ss
S	Spotted Ss	Spotted Ss

could either be heterozygous or homozygous for the allele for spotting. The nanny goat, however, would always be homozygous for the recessive non-spotted allele.

In the first example, we can see that Jacob would claim 50% of the kids and in the second instance 100%. If there was a 50:50 chance of the stud being heterozygous, rather than homozygous, then approximately 75% of all kids born to Laban's flock would become Jacob's. We can reasonably rule out the possibility of the billy goat being homozygous. We can do this because the spotted goats must have been relatively rare in the flock for the scheming Laban to agree to Jacob taking ownership of them. It would require a spotted goat to mate with a spotted goat to produce a homozygous billy goat for the spotted gene. For a mathematical explanation of this, see Table 1. We can see that the transfer of wealth would have been very rapid, with approximately 50% of the offspring from Jacob's breeding programme becoming his.

p^2 = the number of homozygous dominant goats
p = the frequency of the dominant allele (S)
q = the frequency of the recessive allele (s)

$$q = 1 - p$$

In a flock with 5% spotted and given to Jacob, 95% would be non-spotted, hence

$$q^2 = 0{\cdot}95$$
$$q = \sqrt{0{\cdot}95} = 0{\cdot}975$$
$$p = 1 - 0{\cdot}975 = 0{\cdot}025$$
$$p^2 = 0{\cdot}000625$$

Number of homozygous spotted goats would be 0·0625% so the majority of the spotted goats would be homozygous.

In a flock with 10% spotted and given to Jacob, 90% would be non spotted, hence

$$q^2 = 0{\cdot}9$$
$$q = \sqrt{0{\cdot}90} = 0{\cdot}949$$
$$p = 1 - 0{\cdot}949 = 0{\cdot}051$$
$$p^2 = 0{\cdot}002601$$

The percentage of the flock homozygous spotted (SS) would be 0·2601% so again the majority of the spotted goats would be homozygous.

The above calculations apply to the chance of finding a homozygous goat regardless of sex. The billy-goats were present at a ratio of one to twenty, so we can further reduce the chances of finding a male homozygous goat.

Table 1

Possibility 3

Phenotype	Spotted Billy Goat x Spotted Nanny Goat	
Genotype	Ss	Ss

Offspring

	S	s
S	Spotted SS	Spotted Ss
s	Spotted Ss	Non-spotted ss

Jacob's Flock

We have however neglected Jacob's flock of goats which would have also been breeding. Most of these would have been heterozygous (for the same reason as given in Table 1) and when they bred to another heterozygous goat some non-spotted coats would occur. These, of course, would have been returned to Laban's flock as stipulated by the agreement in Genesis 30:33.

From the above example, we can see that Jacob would have had to give all of his own non-spotted kids to Laban. He would be exerting a selection pressure against the recessive allele for non-spotted goat. Over time, this would reduce the frequency of the allele so that a lower percentage of non-spotted kids would be given to Laban each year. This can be followed using the calculations given in Table 2. I have taken into account some of the factors we would reasonably expect, including a high incidence of twins being born[1], which would be capable of breeding the next year. Another factor would be the lifespan of the goats which depends to some extent on the condition of the teeth, but five years would be a conservative estimate[1]. The ratio of male to female goats would be one to twenty due to the majority of male goats being killed for meat. The present of goats to Esau in Genesis 32:14 was in this breeding ratio (Guthrie, 1992).

We have also attempted to build into the calculations an influx of one hundred goats from Laban's flock. With this loss of breeding stock, Laban's flock would probably have failed to grow or even dwindled (Genesis 31:1). The breeding population of goats is enlarged with each additional generation. With a lifespan of five years, the original population of Jacob's goats is removed from the calculations in the sixth year.

The calculations shown here are necessarily simple. Perhaps those with access to computer simulation software could take this study further. I hope that I have demonstrated the genetic principles by which Jacob could have transferred the bulk of Laban's flocks, hence his wealth, during the the six year period in which Jacob carried out his breeding program. During the six years, Laban sought to change the agreement ten times, which demonstrates the rapidity of the transfer of wealth!

Table 2: Hardy-Weinberg and Jacob's Flock[2]

(Incorporating an annual migration of 100 heterozygous spotted goats from Jacob's controlled matings, with all non-spotted goats being placed with Laban's herd.)

YEAR 1

Phenotype	**SPOTTED**	**SPOTTED**	**NON-SPOTTED**
Genotype	**SS**	**Ss**	**ss**
No. of goats (Total=100)	100		0
Phenotype frequency	1		
Genotype frequency		1·00	
Goat herd composition Gene frequency	p=0·5		q=0·5
Reproduction Genotype frequency in offspring	0·25	0·50	0·25
No. of goats before Laban's are removed	25	50	25

YEAR 2

New goat herd composition No. of kids from own herd	25	50	0
Previous herd		100	
Incoming goats from Laban		100	
New herd size (275) by phenotype	25	250	
Gene frequency in new herd	p = (2x25)+250 / 2x275 = 0·545		q = 0·455
Reproduction Genotype frequency in offspring	0·297	0·496	0·207
No. of goats before Laban's are removed	82	136	57

YEAR 3

New goat herd composition No. of kids from own herd	82	136	0
Previous herd	25	250	
Incoming goats from Laban		100	
New herd size (593) by phenotype	107	486	
Gene frequency in new herd	p = (107x2)+486 / 2x593 = 0·592		q = 0·408
Reproduction Gene frequency in offspring	0·350	0·884	0·166
No. of goats before Laban's are removed	208	287	98

YEAR 4

New goat herd composition No. of kids from own herd	208	287	0
Previous herd	107	486	
Incoming goats from Laban		100	
New herd size (1188) by phenotype	315	873	
Gene frequency in new herd	p = (315x2)+873 / 2x1188 = 0·632		q = 0·368
Reproduction Genotype frequency in offspring	0·400	0·465	0·135
No. of goats before Laban's are removed	475	552	160

YEAR 5

New goat herd composition No. of kids from own herd	475	552	0
Previous herd	315	873	
Incoming goats from Laban		100	
New herd size (2315) by phenotype	790	1525	
Gene frequency in new herd	p = (790x2)+1525 / 2x2315 = 0·671		q = 0·329
Reproduction Genotype frequency in offspring	0·450	0·442	0·108
No. of goats before Laban's are removed	1042	1023	250

YEAR 6

New goat herd composition No. of kids from own herd	1042	1023	0
Previous herd	790	1525	
Incoming goats from Laban		100	
New herd size (4480) by phenotype	1832	2648	
Gene frequency in new herd	p = (2x1832)+2648 / 2x4480 = 0·704		q = 0·296

Summary of Table 2

Year 1—25% of Jacob's kids are returned to Laban

Year 2—21% of Jacob's kids are returned to Laban

Year 3—17% of Jacob's kids are returned to Laban

Year 4—14% of Jacob's kids are returned to Laban

Year 5—11% of Jacob's kids are returned to Laban

Year 6—9% of Jacob's kids are returned to Laban

N.B. With a large flock of goats Laban is likely to have lost more than 100 kids a year to Jacob.

References

ANON., (1982), *Exploring Genetics with Dogs.* Science Education Resources Pty. Ltd., Australia. p.9.
GUTHRIE, D (1992), *New Bible Commentary.* Inter Varsity Press, Norwich. p.104.
JONES, S. (1993), *Genetics for Beginners.* Icon Books, Avon. p.8.
LAUVERGNE, (1982), *Series of alleles for goat colour in the domestic goat.* Proceedings of the 3rd Conference of Goat Producers, Tuscon. p.548. Quoted in Journal of Heredity, 1988, 79(1):70.
LINDAHL, K. F. (1981), *Genesis of Genetics.* Nature 290(19 March):183.
THOMPSON, J. A. (1992), *Handbook of Life in Bible Times.* Inter Varsity Press, Glasgow.

Notes

1. My father-in-law, Mr. Derek Price, of Clwyd, N. Wales, informs me that he bred both Toggenburg and British Alpine breeds. Both bear twins which can themselves breed in 6 months (in our calculations breeding the next year). Mr. Price has kept goats breeding into their seventh year but, given the harsher conditions, we shortened this to five years.
2. Hardy-Weinberg calculations are based on worked examples for the peppered moth, found in Unit 10 of the Open University course textbook for course S364.

THE AUTHOR

Ewan More is the head of biology in a school in the Isle of Harris. He graduated in biology and chemistry, having also studied geology. He is a member of the Church of Scotland in Tarbert. Ewan's interest is in seeing how Christians should work out their faith in all occupations and circumstances, in his case in education and biology.

Correspondence

Continued from page 3

history, rather than to hundreds of thousands or millions. But chronology is certainly nowhere near being the most important reason why these data are supplied.

Further, Peet's reference to P. J. Wiseman's suggestion that the 'Toledoth' statements of Genesis are colophons, attached to the end of the history with which they deal, rather than headings for what follows (albeit with links to the preceding), is certainly wrong and misleading. This has been decisively demonstrated in an unpublished ThD thesis, by R. Zimmer, at Concordia Seminary, St. Louis. These statements are headings for what follows, just as Genesis 1:1 is a heading for the following chapter [Genesis 1:2 to 2:3].

Finally, Peet is ill-advised to place so much weight on Biran's identification of 'the house of David' in the Tell Dan inscriptions. As Biran himself pointed out, on his recent lecture tour, his interpretation of this inscription (the three parts of it that have been found so far) is still tentative, and we have much more conclusive archæological evidence for the historical existence of the house of David.

References

ARCHER, G. L. (1982), *Encyclopedia of Bible Difficulties.* Zondervan Publishing House, Grand Rapids, p.362.
ARNDT, W. F. and GINGRICH, F. W. (Editors), (1957), *Greek–English Lexicon of the New Testament and Other Early Christian Literature.* Cambridge University Press, Cambridge. The University of Chicago Press, Chicago, Illinois, p.286.
LIGHTFOOT, J. (1979), *A Commentary on the New Testament from the Talmud and Hebraica Matthew—1 Corinthians.* Baker Book House, reprint of the 1859 Oxford University Press Edition, Volume 2, p.402.

Stephen Browne

Thank you for the recent issue of *Origins* which I have found most interesting, especially as my daughter is studying 'The Earth's Early Atmosphere' for GCSE as a part of science.

Spot the Difference!

1. 'The accumulation of facts and arguments on the side of evolution is so great that it can no longer be considered an open question.'
   —*Mark Ridley, Junior Research Fellow, New College, Oxford.* The Problems of Evolution *(1985). Oxford University Press, p.14.*

2. 'The demonstration that no possible combination of known substances, known forms of machinery, and known forms of force can be united in a practicable machine by which men shall fly long distances through the air, seems to the writer as complete as it is possible for the demonstration of any physical fact to be.'
   —*Simon Newcomb, Professor of Astronomy and Mathematics, US Naval Academy and Director, US Naval Observatory.* The Outlook for the Flying Machine *(1906).*

Oil Formation and Exploration

Paul Garner

OIL is of immense importance to the modern world economy. The very word conjures up images of wealth and prosperity. The refinement of crude oil provides petrol for our vehicles, fuel oils for heating and industrial applications, kerosene for jet and rocket engines and home heating, and any number of oils and greases for lubrication of machinery. In addition we obtain a host of petrochemicals. The nations with the largest proven oil reserves are some of the richest in the world (see Table 1).

Oil has also played a significant role in the present-day scientific debate about creation and evolution. Some critics of creationism have argued that young-earth models do not allow enough time for the formation of oil deposits, while others have expressed the view that young-earth geologists would not be able to successfully locate oil (*e.g.* Walley, 1993). In this article, we will examine these arguments to see whether they are justifiable criticisms of the creationist position. Furthermore, we will provide some background information on how oil is formed, and the various techniques used in exploratory work.

How is Oil Formed?

Petroleum is the general term given to all naturally occurring hydrocarbons (organic compounds which contain only carbon and hydrogen), though it is more often used to refer specifically to the liquid oils. The term is derived from the Greek word *petra*, meaning rock, and the Latin word *oleum*, meaning oil. Oil deposits usually occur in sequences of marine sedimentary rocks, although some may have been formed in estuarine or deltaic environments. Natural gas is commonly found in association with oil.

Geologists, of course, have wanted to know where these hydrocarbons came from. How did they form? What processes were involved? Despite the huge amount of research conducted in this field, the answers to these questions are still somewhat elusive. Jenyon (1990, pp.3–4) writes:

> 'It is a salutary thought that, in spite of the massive scientific and technological advance made over the past century, there is *still* no firm consensus as to the originating processes responsible for the development of those hydrocarbons referred to as 'petroleum', whether in solid, liquid, or gaseous state. Some would even say that we still do not know the basic origin of petroleum with any certainty' [emphasis in original].

Over the years, a number of scientists have proposed that oil and gas deposits had an inorganic origin. For instance, in the late nineteenth century, Dmitri Mendeléev, a great Russian chemist, hypothesised that oil was formed by chemical reactions deep within the earth. Others argued for a cosmic origin, in which hydrocarbons precipitated from the primordial solar nebula were incorporated into the earth's interior, later making their way into the near-surface environment (North, 1985, p.37). More recent proponents of an inorganic origin for petroleum include V. B. Porfir'ev of the Institute of Geological Sciences at the Academy of Sciences in the Ukraine (Porfir'ev, 1974), Dr. Thomas Gold of the Centre for Radiophysics and Space Research of Cornell University, New York (Gold, 1986), and Giardini and Melton (1983) in the USA. However, the vast majority of geologists believe that oil and gas had an organic origin—that is to say that oil and gas were derived from biological substances, such as plant and animal debris. Of course, an undetermined proportion of our oil and gas reserves may be of inorganic origin, but this in no way excludes a biological origin for the majority of our oil and gas. An exclusively inorganic origin is supported today by only a small number of scientists.

Some authors have claimed that the organic origin of oil presents a serious problem for young-earth creationists. They argue that it is not possible to account for the total amount of carbon in coal and oil in the short time scale of young-earth creationism, unless most of the coal and oil is

GLOSSARY

Kerogen: a solid, organic material which yields petroleum hydrocarbons on heating and distillation.

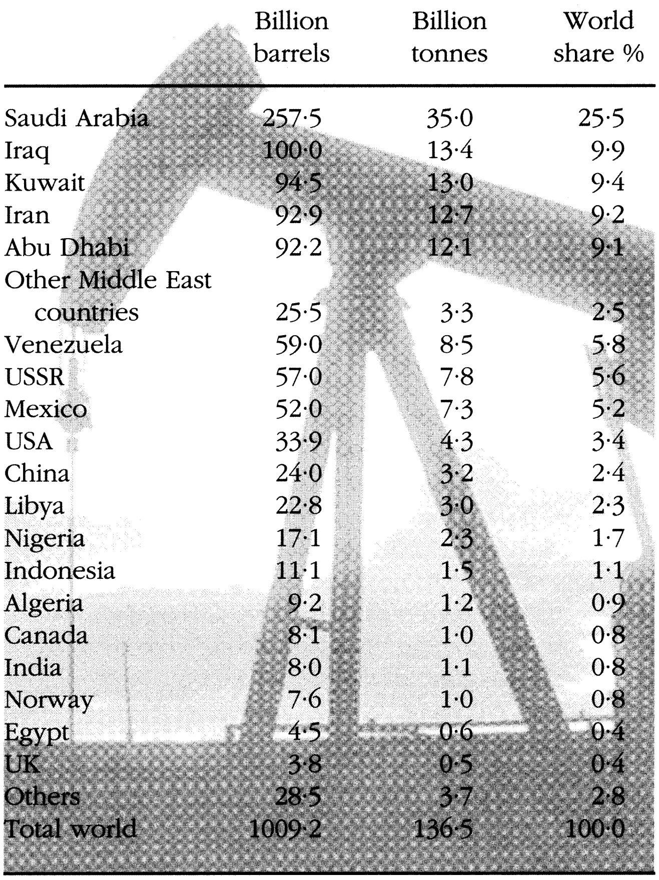
Micelles: colloidal aggregates with the unique property of being able to solubilize both hydrophobic and hydrophilic compounds.

Vitrinite: one of the three main individual consistuents found in coals. These constituents are called macerals (from the verb, *macerate).*

inorganic in origin (Morton, 1984a). However, these calculations have been challenged by Woodmorappe (1986) who has shown that, even without inorganic carbon sources, the total carbon in coal and oil deposits poses no problem for a young earth.

Table 1: Proven reserves of oil, 1990

(From BP Statistical Review of World Energy, 1991)



	Billion barrels	Billion tonnes	World share %
Saudi Arabia	257·5	35·0	25·5
Iraq	100·0	13·4	9·9
Kuwait	94·5	13·0	9·4
Iran	92·9	12·7	9·2
Abu Dhabi	92·2	12·1	9·1
Other Middle East countries	25·5	3·3	2·5
Venezuela	59·0	8·5	5·8
USSR	57·0	7·8	5·6
Mexico	52·0	7·3	5·2
USA	33·9	4·3	3·4
China	24·0	3·2	2·4
Libya	22·8	3·0	2·3
Nigeria	17·1	2·3	1·7
Indonesia	11·1	1·5	1·1
Algeria	9·2	1·2	0·9
Canada	8·1	1·0	0·8
India	8·0	1·1	0·8
Norway	7·6	1·0	0·8
Egypt	4·5	0·6	0·4
UK	3·8	0·5	0·4
Others	28·5	3·7	2·8
Total world	1009·2	136·5	100·0

* Conversion based on average (Arabian light oil) 33·5° API gravity

Stages in the Formation of Oil

Oil is generally considered to be the result of the decay of plant material under anaerobic conditions—in other words, in the absence of free oxygen—with marine plankton considered to be the major contributor. Thus, the first stage in the process of oil formation is thought to be the accumulation of fine-grained muds, rich in planktonic remains. Under the appropriate conditions—in shallow, warm, oxygen-rich, nutrient-rich bodies of water—phenomenal populations of plankton can be generated. This is the phenomenon of waterbloom (North, 1985, p.44), where the production of micro-organisms is so great that the water becomes coloured (*e.g.* the documented annual 'red tides'). To transform this organic matter to petroleum, the oxygen and nitrogen of the original material must be removed, to leave a hydrocarbon residue. This transformation is not possible in an oxygen-rich environment or if the organic matter is exposed to prolonged transport in oxidising conditions. Therefore, oil only accumulates if the organic matter is rapidly transported into an anaerobic environment, and is protected from consumption by bottom-dwelling organisms. Rapid burial appears to be an essential element in the successful generation of oil in the natural environment. This is emphasised by Muir Wood (1978, p.105) who says, 'in the sea the dead animal and plant matter must be rapidly buried in mud at the sea bottom to have a chance of preservation, without becoming part of some other organism's food chain.'

How do creationists integrate these facts into their young-earth model? As Biblical creationists, we take seriously the scriptural record of Noah's Flood and seek to follow through the implications of such an event in our scientific reconstructions of earth history. During the global catastrophe of Noah's day, it is reasonable to assume that planktonic blooms were generated on a scale scarcely conceivable today. Suggested factors in promoting waterblooms include turbulence of the sea, wind, decaying fish, nutrient supply from freshwater inflow and upwelling, and increased water temperature (Snelling, 1994, p.13). All of these phenomena would be expected in an upheaval like the Flood and also probably persisted for several centuries after that event. At the same time, sediment supply and deposition rates would be significantly increased. The combination of planktonic waterblooms with rapid sediment accumulation would have provided ideal conditions for the accumulation of hydrocarbon deposits.

The next step in the process of petroleum generation involves progressive decomposition of the planktonic matter under conditions of increasingly deep burial. This leads to the formation of an amorphous, unstructured type of kerogen (Type I kerogen) called sapropel. According to Jenyon (1990, p.6), the stage after sapropel formation 'is fraught with controversy'. Perhaps the most widely held view among geologists is that petroleum is generated by the destructive distillation of kerogen under suitable conditions of temperature and pressure, although as Jenyon points out, 'there are difficulties in accepting this view' (p.6). Some geologists believe that kerogen itself is not the originating material, but that it acts as a carrier of the substances that do, in fact, form the 'protopetroleum'.

Although the chemical and physical processes by which the conversion from kerogen to 'protopetroleum' takes place are still not properly understood, they must occur at less than 200°C. This constraint derives from the fact that oil-soluble organometallic compounds called porphyrins are found in most crude oils, and these compounds cannot survive temperatures in excess of 200°C. The presence of porphyrins is also significant in determining the source material for oil, since these compounds have a chemical structure very similar to chlorophyll, the pigment found in plants.

It is obvious that there are still many question marks hanging over our models of oil formation. Many issues remain unresolved, with little or no consensus in the scientific community. It would be unwise in view of the uncertainties involved for opponents of creationism to dogmatically assert that oil formation cannot be explained by young-earth models. As Jenyon (1990, p.24) has reminded us:

> 'It should thus be borne in mind that the current thermochemical concept of petroleum genesis is only a 'working hypothesis', which may be abandoned or substantially modified when a model is presented that better fits all the known facts.'

How Long does it Take to Form Oil?

Elementary geology texts usually emphasise the ponderously slow nature of the processes that generate oil. For instance, Matthews (1970, p.151) writes, 'Although the processes by which the organic material was finally converted to petroleum are not thoroughly understood, *they appear to have required vast amounts of time*, accompanied by increased temperature and compression of the sediments' [my emphasis]. If it is true that vast amounts of time are required for petroleum generation, then the young-earth theory is falsified. However, a more thorough examination reveals that long time periods are not required—more often they are simply assumed. This is another example of the dominance of Lyellian uniformitarianism in geological thought.

An interesting paper by Dr. Leigh Price was published in 1983 in the *Journal of Petroleum Geology*. In contrast to claims that vast periods of geological time are necessary for the formation and maturation of oil, Dr. Price provides evidence that full organic maturation is achieved by, *at most*, one million years. In fact, he cites vitrinite reflectance data from recently-heated geothermal regions which suggest that the heating (burial) times necessary for full organic maturation may be in the order of only 1,000–10,000 years! In Dr. Price's view, the accepted model of petroleum generation and maturation is 'largely in error' and requires at the very least substantial revision (p.32). Jenyon (1990, p.7) has commented:

> 'The implications of Price's study seem to be that petroleum generation is in many, perhaps most, cases more dependent on what might be thought of as 'pulses' in the palæogeothermal gradient owing to major geological events with accompanying high heat flow—such as incipient or aborted rifting, extrusive/intrusive igneous activity, hydrothermal activity, and orogenesis.'

The significance of this for a creationist view of oil formation will become more clear when we discuss hydrothermal oil generation in the Guaymas Basin (see below).

Laboratory experiments have generated petroleum in very short periods of time under conditions simulating those occurring naturally in a sedimentary basin. This research was carried out between 1977 and 1983 by workers at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) laboratories in Sydney, Australia. The researchers used a Permian oil shale (torbanite) from Glen Davis, New South Wales, and a Tertiary brown coal (lignite) from Loy Yang in the Latrobe Valley, Victoria as source rocks for their experiments. Dr. Andrew Snelling (1990, p.31) has summarised the methodology involved in these experiments:

> 'These two source rock samples were each split into six sub-samples, and each sub-sample was individually sealed in a separate stainless steel tube. The two sets of six stainless steel tubes were then placed in an oven at 100°C and the temperature increased by 1°C each week. After 50, 100, 150, 200, 250 and 300 weeks (that is, at maximum temperatures of 150°C, 200°C, 250°C, 300°C, 350°C and 400°C) one stainless steel tube from each series was removed, cooled and opened. Any gas in each tube was sampled and analysed. Residues in each tube were extracted and treated with solvents to remove any oil, which was then analysed. The solid remaining was also weighed, studied, and analysed.'

The conditions chosen by the researchers are probably the best attempt so far to duplicate the natural conditions in a subsiding sedimentary basin. The results were quite startling (Saxby and Riley, 1984; Saxby *et al.*, 1986). During the first 150 weeks the oil shale sample showed little reaction. By 300°C, 35% of the oil shale had been converted to a paraffinic crude oil. At 350°C, not only was generation of the oil complete, but extensive 'cracking' of the oil had taken place. Thermal decomposition of the oil had produced 60% gas and 40% fine-grained inertinite ('petroleum coke'). By 400°C, cracking had advanced further, and all traces of oil had disappeared.

In the brown coal samples, little change occurred during the first 50 weeks of heating, but gas was produced at an increasing rate over the next 100 weeks. Up to this point virtually no oil was formed. Between 250°C and 300°C the brown coal produced about 1% short-chain hydrocarbons and 0·2% oil. This trace of oil resembled a natural light crude oil—similar to that commercially recovered from Bass Strait, the offshore oil field in the same sedimentary basin, and stratigraphically above, the Latrobe Valley coal beds from which the experimental sample came. After 250 weeks (350°C), the products resembled a carbon dioxide-rich natural gas. At these temperatures, the brown coal was converted to anthracite (a high-grade black coal).

In these experiments, the products were strikingly similar to natural petroleum, and they had been generated in only six years! Additional evidence for rapid oil formation is provided by the discovery of patches of 'young' petroleum in deep ocean springs in the Gulf of California (Simoneit and Lonsdale, 1982). In an area known as the Guaymas Basin, there is a series of deep fractures linking volcanoes of the East Pacific Rise with the San Andreas Fault system. These fractures cut through 500 metres of diatomaceous ooze and silty mud which infill two rift valleys. Along these fractures flows hydrothermal water at temperatures in excess of 200°C. These hydrothermal fluids are discharging oil globules up to 1–2 centimetres in diameter into the ocean water. In addition, disturbance of the sediments is also releasing oil globules. Precise measurement of the oil flow rate at these sites has not proved feasible thus far, but the *in situ* collection of oil globules shows that the gas/oil ratio is about 5:1 (Snelling, 1990, p.33).

The Guaymas Basin hydrothermal oil is similar to naturally-occurring reservoir crude oils (Didyk and Simoneit, 1989, p.66), and has probably formed by the action of hydrothermal fluids on organic matter in the diatomaceous sediments. Analytical techniques give results that are consistent with a predominantly bacterial/algal origin (Didyk and Simoneit, 1989, p.66). Of great significance are the radiocarbon dates yielded by the oil. The radiocarbon dates range from 4240 to 5705 years B.P. (Peter *et al.,* 1991), demonstrating that conversion of organic matter into petroleum compounds has taken place over a very short geological time scale (<5,000 years) under relatively mild temperature conditions.

Most commercial oil and gas reserves are thought to have been the result of long-term heating and maturation of organic matter, with successive stages of alteration, as we have previously outlined. This kind of multi-step process is significantly different from the one-step hydrothermal process taking place in the Guaymas Basin. It is not yet clear what contribution this single-step hydrothermal process has made to the origin of the earth's oil reserves, but it should certainly be considered in future resource exploration (Peter *et al.,* 1991). It is interesting that it generates products that are identical to known natural crude oils, and it may have significant implications for our understanding of petrolem formation. The discovery of hydrothermal oil is of particular interest to creationists, who envisage a tremendous amount of hydrothermal activity during Noah's Flood as a result of the breaking up of 'the fountains of the great deep' (Genesis 7:11). Such an event would have generated superheated water, lavas, volcanic gases, and mineral-bearing fluids. There is great potential here for the development of catastrophist models for oil and gas formation during the Flood.

Oil Migration

Probably about 60% of oil occurs in sandstones and about 30% in limestones and dolomites (Duff, 1993 p.129). However, on average, sandstones contain only 0·56% organic matter and limestones 0·5%, compared with an average 1·2% for shales (Duff, 1993, p.130). It is obvious, therefore, that exploited reservoir rocks contain more oil and gas than could possibly have formed *in situ.* Oil and gas pools are formed by migration of petroleum compounds from source rocks (where the oil or gas was generated) into reservoir rocks (through which the oil or gas flows).

The initial movement of petroleum out of its source rocks is referred to as primary migration, while secondary migration describes movement through reservoir rocks into what are called oil traps (see next section). According to Jenyon (1990, p.25):

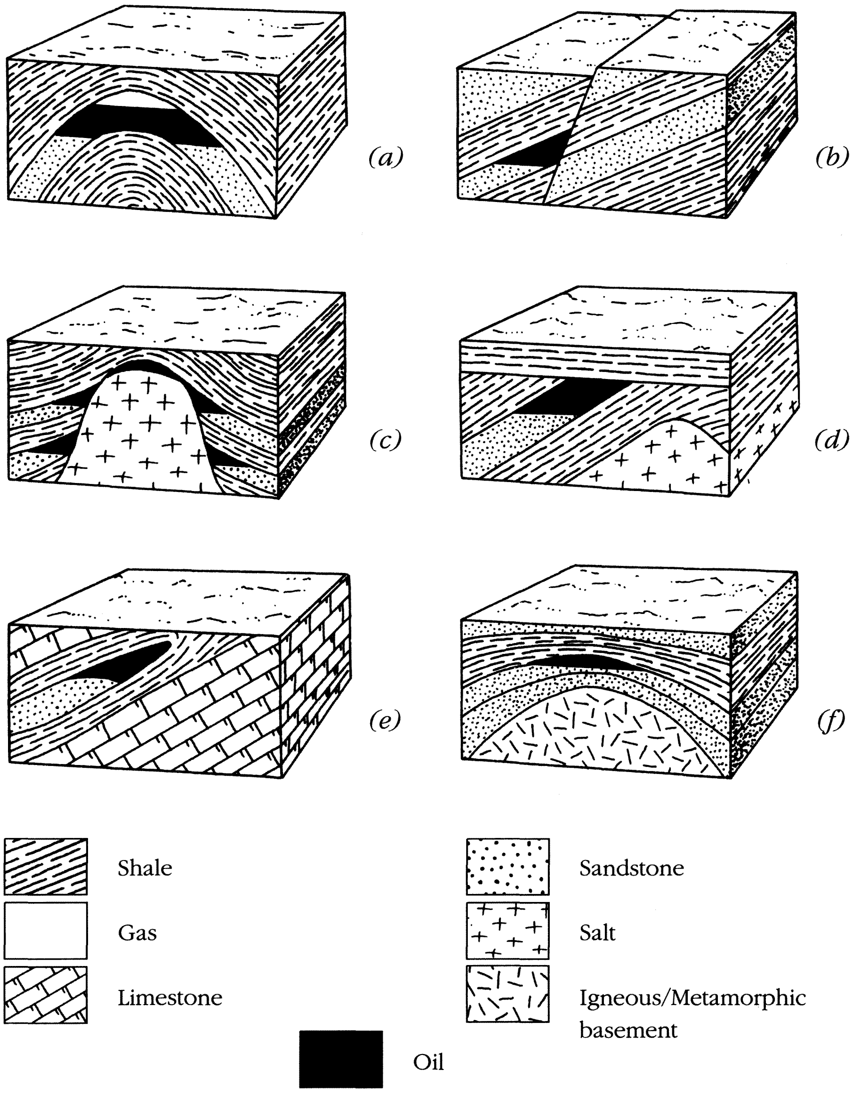
> 'The processes and controls governing secondary migration are reasonably well understood. However, the same cannot be said of primary migration. The manner in which newly formed petroleum moves out of the source rock involves problems that still puzzle geologists.'

Primary migration may be partly the result of squeezing of water and petroleum compounds out of the source rocks due to the loading of overlying sediments. However, borehole data shows that compaction of the source rocks is virtually completed at depths where temperatures are not high enough for the formation of many petroleum compounds (Duff, 1993, p.130), so this cannot be the entire answer. It may be that continued oil and gas formation produces such pressures that microfractures occur in the source rocks, allowing the petroleum compounds to escape. If the primary migration of oil is related to water movement, as current models suggest, another problem presents itself. Within the temperature window thought to be normal for oil generation, oil is practically insoluble in water (Jenyon, 1990, p.25). So if the oil is not in solution, how does water influence oil migration? There have been suggestions that another form of solution—micellar solution—may have been involved (Baker, 1962), but other authors consider this implausible (Magara, 1977). Various hypothetical mechanisms for primary oil migration have been proposed, but there is a lack of general agreement among experts, and debate continues on this topic (Jenyon, 1990 p.27).

Secondary migration is thought to transport the oil and gas upwards and sideways due to: *(a)* the buoyancy of the oil and gas relative to the water filling the pores, joints, and fissures in the reservoir rocks, and *(b)* movement of water through the reservoir rocks (Duff, 1993, p.131).

Oil and Gas Traps

In cases where migration is unhindered, oil may reach the surface, the liquid proportion evaporates, and solid waxes and asphalts are left behind. Oil and gas deposits are only commercially exploitable if the petroleum compounds become trapped in the subsurface environment, and upward and lateral migration is impeded. Thus, an oil or gas trap may be defined as 'any arrangement of strata that permits the accumulation of hydrocarbons in commercial quantities' (North, 1985, p.254). A trap has two functions: it receives the hydrocarbons, and it prevents their escape. However, traps are not passive receivers of oil or gas into an otherwise empty space. Most traps are originally water-wet; in other words, oil and gas displace pore-water in the trap as they accumulate. As oil and gas are depleted from a trap by commercial exploitation, water again floods the trap. Traps are, therefore, 'focal points of active fluid exchange' (North, 1985, p.254).



Geological block diagrams to illustrate the various types of traps favourable to the accumulation of oil and gas: *(a)* anticlinal trap; *(b)* fault trap; *(c)* salt dome trap; *(d)* unconformity trap; *(e)* pinch-out or wedge-edge trap; *(f)* topographic trap [Diagram by Russell Grief]

There are a great variety of traps, but all consist essentially of porous rock enclosed in, or capped by, relatively impervious rock. About 62% of the caprocks for the world's 176 giant gas fields are shales, and about 38% are evaporites (Grunau, 1981). Two major groups of trap can be recognised: structural traps and stratigraphic traps. Structural traps are those formed by any secondary, post-depositional arrangement of the strata (*e.g.* folding, faulting). Stratigraphic traps are those created by any primary variation in the stratigraphy that is independent of structural deformation (*e.g.* unconformities, lens-shaped sand bodies, reef limestones, buried topography). The accompanying diagrams illustrate some basic types of oil and gas trap. I should point out that the distinction between structural and stratigraphic traps is not always as clear cut as I have portrayed here. Many oil and gas fields will have combination traps which are both structural and stratigraphic. In fact, any attempt to produce a neat classification is bound to create overlap and ambiguities (North, 1985, p.259).

Some of the most areally extensive oil and gas fields in the world are essentially stratigraphic traps. The largest oil field in the Western Hemisphere, the Bolivar Coastal field in Venezuela, contained original recoverable reserves of about 5 x 10^9 m^3 (30 billion barrels) in an essentially stratigraphic trap. Other examples of giant stratigraphic traps include the East Texas oil field, the Hugoton gas field, the Lima–Indiana field, and the offshore Pembina field of Canada (North, 1985, pp.255–6). There are also many smaller examples around the world.

The Age of Oil and Gas Deposits

As we saw above, oil and gas deposits are normally found in a porous and permeable rock (*e.g.* sandstone) which is sealed by an impermeable rock (*e.g.* shale). In many cases, it is thought to have been tens or hundreds of millions of years since the oil or gas was first emplaced in the trap. Such vast time periods are obviously not compatible with young-earth models which predict only a few thousand years since oil or gas formation and entrapment. Is there any scientific evidence which suggests that entrapment of the oil or gas might have occurred more recently than long-age models imply? The answer to this question seems to be yes. Three lines of evidence for a young age have been outlined by Morton (1984b). These are described below.

Although natural gas has difficulty in travelling through an impermeable cap rock, it can travel through very slowly. No sedimentary rock is totally impermeable (North, 1985, p.125). A study of the diffusion of light hydrocarbons through and from shales has shown that the destruction of entire gas fields can be accomplished by this process (Leythaeuser *et al.*, 1982). For instance, calculations of the rate of destruction of the Harlingen gas field, Holland, show that methane in these Lower Cretaceous reservoir sands can escape through a 400 metre shale cap with a half-life of 4·5 million years. Furthermore:

> 'Assuming smaller thicknesses of the shale cap rock of 300m, 200m, and 100m, this period would be reduced to 2·7, 1·3, and 0·4 million years, respectively. Thus, diffusion of light hydrocarbons in the subsurface can

also have economically adverse effects: existing gas accumulations can be destroyed by dissipation in rather short periods of geologic time' (Leythaeuser *et al.,* 1982 p.426).

On the basis of such calculations, the authors propose (p.426):

> '... that gas accumulations in the subsurface have only a limited life in terms of geologic time scales. If this is true, known gas fields in older strata like lower Palæozoic reservoirs can be explained only by assumption of a relatively young accumulation age or by the assumption of a much longer duration of the hydrocarbon generation process than currently accepted.'

In other words, gas deposits are either in a steady-state equilibrium with loss through the cap rock being continually balanced by replenishment from the source rocks, or they are young in age. These data are certainly consistent with young-earth models.

A second indication that oil and gas pools are young is the abnormal pressure encountered in many reservoirs. Usually, the pressure of fluids found in rocks is equal to the weight of the overlying rocks (hydrostatic pressure). However, certain conditions may cause the pressure within an oil reservoir to exceed that due to the overburden. This may result from rapid loading of further sediments, or folding and faulting of the sequence (Dickey *et al.,* 1968; Morton, 1984b, p.229). In such instances, the oil wells produce 'gushers' if the flow of oil is not controlled. A dramatic photograph of a 'gusher' at the Lucas oil well, Spindletop, Texas in 1901 was reproduced on the cover of the March 1984 issue of the *Creation Research Society Quarterly* to accompany Morton's paper. The well was 1,020 feet deep when it began to flow. The pressure pushed 700 feet of drill pipe out of the hole, and the oil gushed 200 feet into the air. Modern drilling techniques control underground pressures and prevent 'gushers' like this one. Abnormal underground pressures like this are transient and dissipate over time as a result of slow leakage of fluid through the impermeable cap. Unless they are maintained by continuing dynamical activity, such excessive pressures can only last for relatively short periods of geological time. As one evolutionist has pointed out, 'Some geologists find it difficult to understand how the great pressures found in some oil wells could be retained over millions of years' (Stansfield 1977, p.82). This is, again, consistent with a young age for these oil pools.

Finally, Morton (1984b, p.230) points to the lack of ancient destroyed oil reservoirs which we would expect to find if the long-age model is correct. He quotes Porfir'ev (1974, p.23) who says:

> 'One sees progressively metamorphosed coal accumulations in the stratigraphic record but never comparably altered or destroyed oil accumulations.'

The reader is also directed to a paper by Snelling (1982) on the origin of oil and gas in the Gippsland sedimentary basin under Bass Strait, southeastern Australia. The evidence from this region suggests the recent, rapid burial of coal-bearing sediments, followed by rapid generation of hydrocarbons, and very rapid migration of the oil and gas into traps. Recent origin is supported by the fact that the hydrocarbon traps were full when they were discovered, and that the oil in the reservoirs was low in sulphur, indicating that there has not been time for extensive alteration by bacteria and other processes. In fact, oil and gas are still being formed there today.

Oil Exploration: an Evolutionary Pursuit?

Critics sometimes claim that application of the young-earth creationist model would be unfruitful in oil exploration. These critics point out that professional geologists—most of whom accept the long-age, uniformitarian model of earth history—are successful in locating oil. This they see as a vindication of the long-age, uniformitarian model. In other words, the critics challenge creationists with the claim that evolutionary theories work in practice. How weighty is this argument?

First, is it really true that oil geologists rely upon evolutionary theory in their work? Certainly, most geologists in the oil industry are evolutionists and accept the long-age geological time scale. But are these beliefs crucial to their success in locating oil deposits? The answer is no! To confirm this, let us look briefly at the techniques used in oil exploration.

Occasionally, significant discoveries are made by accident. The modern oil industry began in the United States in 1848 when boring for water brought up oil in Pennsylvania. Similarly, the vast natural gas reserves of western Canada were first discovered in 1883 while looking for water during the construction of the Canadian Pacific Railway (Duff, 1993, p.128). But in planned exploration, the first step is fieldwork—the mapping of surface geological features in virgin territory, and the recording of surface 'shows' of oil and gas. Surface evidences of hydrocarbons include seepages, mud volcanoes, burnt clays, and sulphur or gypsite in soils (North 1985 p.395). Information can be gained from aerial and satellite photography—tonal anomalies on photographs may indicate surface hydrocarbons. As a matter of fact, most contemporary exploratory work is carried out in areas that are already well mapped but which have not previously been considered as possible oil and gas sites, or in remote and poorly accessible regions where surface fieldwork is difficult to carry out. Such areas are expensive to explore and there is a high risk of failure.

Although surface studies can be helpful, geophysical methods and the drilling of boreholes are essential to prove the existence of oil and gas. One of the most effective geophysical techniques used is seismic reflection profiling, which can be carried out on land or at sea. This involves a series of controlled explosions at chosen sites to produce artificial shock waves similar to those produced by earthquakes. Some of the wave energy is reflected back to the surface when the waves encounter certain physical features in the rocks (*e.g.* changes in bedding, unconformities, faults). Detectors called geophones or hydrophones are used to record the time taken for the reflected wave energy to reach the surface, and these results can be used to calculate the depth of the reflective features in the rocks. In this way, a picture of the underground structure of an area can be pieced together. Most of the North Sea oil and gas reservoirs discovered since 1964 have been located by such methods.

Detailed knowledge of an area is also built up by drilling. Drilling rigs at sea can be operated from ships, from floating platforms, or from jack-up rigs which have legs resting on the sea floor. When drilling of a hole is complete, geophysical instruments called sondes are lowered into the hole at the end of a wire. These instruments record the physical properties of the rocks, to produce a wireline log. The log records changes in electrical potential and resistivity, radioactivity, and density of the various strata. Combined with palæontological studies, a detailed picture of the stratigraphic sequence of a region is constructed.

The first exploratory hole drilled in a prospective area is called a wildcat well. It is not often realised that only one or two boreholes in ten actually find any oil or gas (Kennett and Ross, 1983, p.21), and only about one well in fifty produces enough oil to pay for itself (Morris, 1994). Nevertheless, even the 'dry' holes make an invaluable contribution to our understanding of the structure and stratigraphy of a region (Kennett and Ross, 1983, p.21), and it is clear that the methods used in oil exploration are effective enough to make the industry huge amounts of money!

In short, geologists are looking for a region where there are appropriate hydrocarbon source rocks, reservoir rocks, a migration route from source to reservoir, and a trap configuration with a sealing formation (caprock). The methods by which they carry out this search are summarised by McQueen (1986, pp. i–ii):

> 'The classic problem faced by the petroleum industry, since its U.S. inception by Drake in 1859, has always been how to find underground traps of the oil by looking and experimenting at the earth's surface. This is accomplished today by measuring folds and faults (structural geology), studying the detailed sequence of rocks in an area (stratigraphy), and testing using artificial earthquake energy (seismic exploration).'

None of these methods depends upon acceptance of evolution. No doubt some will object that biostratigraphy is fundamentally evolutionary, and some creationists may be tempted to agree. Biostratigraphy is the study of the fossil sequence, with microfossils being of particular importance to the petroleum geologist. But it is not necessary to read biostratigraphy through evolutionary-tinted spectacles! Even the anti-creationist writer, Steven Schafersman, admits that biostratigraphers employed in the oil industry 'never use evolution in their work' (1983, p.228). As Michael Garton has argued in this journal, the fossil sequence is independent of evolutionary theory and the millions-of-years time scale. He put it this way (1990, p.9): 'The sequential order is a matter of geometry: which layers of the onion are on top of which. Geometry can be checked out and proven. Conversely, evolution has not been verified; it remains without proof.' Similarly, geologist Dr. John Morris says (1993), 'Oil exploration consists primarily of the search for a particular underground geometry where oil might be trapped in the rocks. 'Oil is where you find it', as they say; the age of the rocks or the source of the oil is not of importance. Without doubt, beds can be correlated by studying microfossils, but this has nothing to do with age or evolutionary ideas.'

Of course, we will only know for sure whether creationist modelling is helpful in locating oil when it is tested out! Unfortunately, at least one proposal to fund a small team of catastrophist geologists in developing an exploration programme has already been turned down (Morris, 1994).

Conclusions

Geological and geophysical evidence indicates that the oil deposits of the world could have been formed rapidly and recently. Experimental data and field observations support the idea that oil can form quickly given the appropriate conditions. Creationists propose that the global catastrophism associated with Noah's Flood and its aftermath would provide these conditions.

The claim by some critics, that successful oil exploration is based on evolutionary concepts, is false. Oil exploration uses methods that are completely independent of evolutionary theory, and they work regardless of the particular model of origins favoured by the oil geologist.

References

BAKER, E. G. (1962), *Distribution of hydrocarbons in petroleum.* Bulletin of the American Association of Petroleum Geologists, 46: 76–84.

DICKEY, P. A., SHRIRAM, C. R. and PAINE, W. R. (1968), *Abnormal pressures in deep wells of southwestern Louisiana.* Science, 160: 609–615.

DIDYK, B. M. and SIMONEIT, B. R. T. (1989), *Hydrothermal oil of Guaymas Basin and implications for petroleum formation mechanisms.* Nature, 342: 65–69.

DUFF, D. (1993), *Holmes' Principles of Physical Geology.* Chapman & Hall, London.

GARTON, M. (1990), *Rocks and Scripture: investigating the earth's history.* Origins, 3(9): 4–9.

GIARDINI, A. A. and MELTON, C. E. (1983), *A scientific explanation for the origin and location of petroleum accumulations.* Journal of Petroleum Geology, 6: 117–138.

GOLD, T. (1986), *Oil from the centre of the Earth.* New Scientist, 110(1514): 42–46.

GRUNAU, H. R. (1981), *Worldwide review of seals for major accumulations of natural gas.* Bulletin of the American Association of Petroleum Geologists, 65: 933.

JENYON, M. K. (1990), *Oil and Gas Traps: Aspects of their Seismostratigraphy, Morphology, and Development.* John Wiley & Sons, Chichester.

KENNETT, P. and ROSS, C. A. (1983), *Geophysics.* Longman Group Limited, York.

LEYTHAEUSER, D., SCHAEFER, R. G. and A. YUKLER. (1982), *Role of diffusion in primary migration of hydrocarbons.* Bulletin of the American Association of Petroleum Geologists, 66:408–429.

MAGARA, K. (1977), *Petroleum migration and accumulation,* in Hobson, G. D. (editor), Developments in Petroleum Geology, Volume I. Applied Science Publishers, London. pp.83–126.

MATTHEWS, W. H. (1970), *Geology Made Simple.* W. H. Allen, London.

McQUEEN, D. R. (1986), *The chemistry of oil explained by Flood geology.* ICR Impact article 155.

MORRIS, J. D. (1993), *Is creation thinking useful?* ICR Acts & Facts, Back to Genesis insert 52.

MORRIS, J. D. (1994), *It helps to think creation.* Creation Ex Nihilo, 16(4): 24–25.

MORTON, G. R. (1984a), *The carbon problem.* Creation Research Society Quarterly, 20:212–219.

MORTON, G. R. (1984b), *The age of oil and gas.* Creation Research Society Quarterly, 20:229–230.

MUIR WOOD, R. (1978), *On the Rocks: A Geology of Britain.* BBC Books, London.

NORTH, F. K. (1985), *Petroleum Geology.* Allen & Unwin, London.

PETER, J. M., PELTONEN, P., SCOTT, S. D., SIMONEIT, B. R. T. and KAWKA, O. E. (1991), *^{14}C ages of hydrothermal petroleum and carbonate in Guaymas Basin, Gulf of California: implications for oil generation, expulsion, and migration.* Geology, 19: 253–256.

PORFIR'EV, V. B. (1974), *Inorganic origin of petroleum.* Bulletin of the American Association of Petroleum Geologists, 58: 3–33.

PRICE, L. C. (1983), *Geologic time as a parameter in organic metamorphism and vitrinite reflectance as an absolute paleogeothermometer.* Journal of Petroleum Geology, 6: 5–38.

SAXBY, J. D. and RILEY, K. W. (1984), *Petroleum generation by laboratory-scale pyrolysis over six years simulating conditions in a subsiding basin.* Nature, 308:177–179.

SAXBY, J. D., BENNETT, A. J. R., CORCORAN, J. F., LAMBERT, D. E. and RILEY, K. W. (1986), *Petroleum generation: simulation over six years of hydrocarbon formation from torbanite and brown coal in a subsiding basin.* Organic Geochemistry, 9: 69–81.

SCHAFERSMAN, S. D. (1983), *Fossils, stratigraphy, and evolution: consideration of a creationist argument,* in Godfrey, L. R. (editor), Scientists Confront Creationism. W. W. Norton & Company, New York. pp.219–244.

SIMONEIT, B. R. T. and LONSDALE, P. F. (1982), *Hydrothermal petroleum in mineralized mounds at the seabed of Guaymas Basin.* Nature, 295:198–202.

SNELLING, A. A. (1982), *The recent origin of Bass Strait oil and gas.* Ex Nihilo Technical Journal, International Edition, 1(2): 43–46.

SNELLING, A. A. (1990), *How fast can oil form?* Creation Ex Nihilo, 12(2):30–34.

SNELLING, A. A. (1994), *Can Flood geology explain thick chalk layers?* Creation Ex Nihilo Technical Journal, 8:11–15.

STANSFIELD, W. (1977), *The Science of Evolution.* Macmillan, New York.

WALLEY, C. J. (1993), *Geology made sinful?* Evangelicals Now, (October): p.16.

WOODMORAPPE, J. (1986), *The antediluvian biosphere and its capability of supplying the entire fossil record,* in Walsh, R. E., Brooks, C. L. and Crowell, R. S. (editors), Proceedings of the Second International Conference on Creationism, Volume II. Creation Science Fellowship, Pittsburgh. pp.205–218.

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—*Jean Robinson,* Contemporary lessons from Nazi medicine. *Institute of Medical Ethics Bulletin, 1989, (47): 14.*

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